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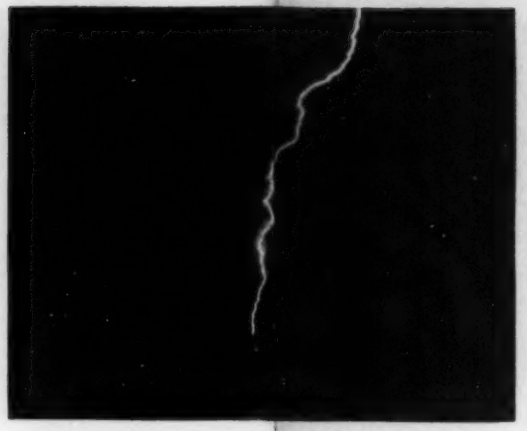
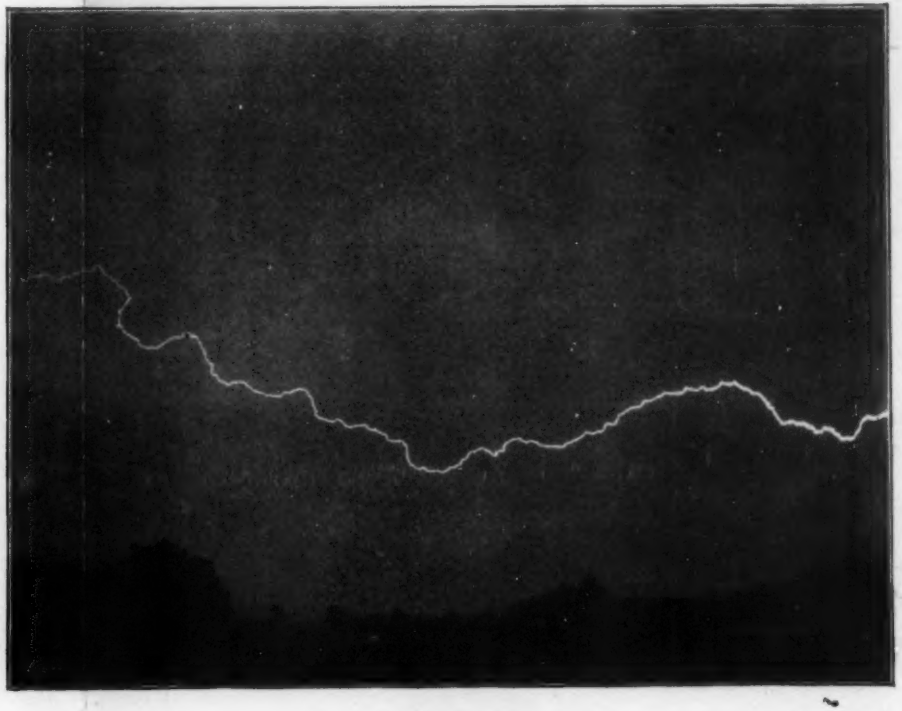
(8) Loop form of lightning.



(11) Vertical discharge with dark branches.

(12) Parallel discharge converging into one main stem.

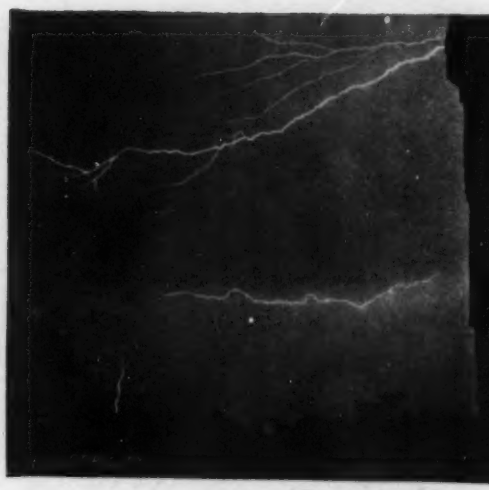
(9) Meandering discharge.



(10) Horizontal discharge.

VARIOUS FORMS OF LIGHTNING DISCHARGES. (Reproduced from photographs by W. N. Jennings.)

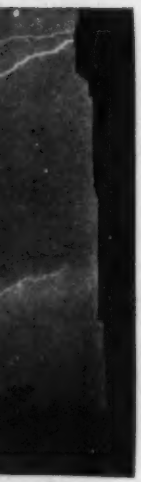
(6) Divided discharge.



(7) Double horizontal discharge. (Simultaneous

(8) Loop form of lightning.

(11) Vertical discharge



multaneous.)

(9) Meandering discharge.

VARIOUS FORMS OF LIGHTNING DISCHARGES. (Reproduced from photographs

(4) Tree" form of lightning.

(5) Vertical stratified discharge.

by W. N. Jennings.)

JOURNAL

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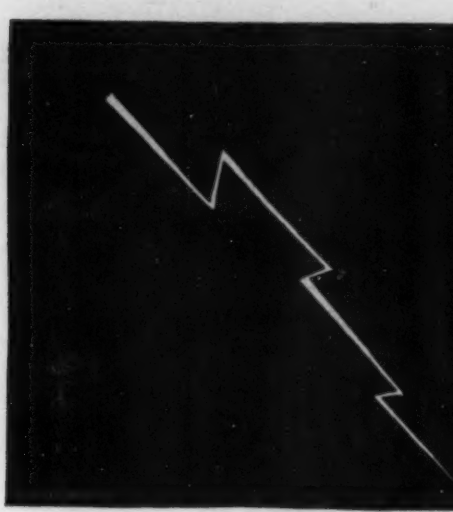
THE UNITED STATES LIFE-SAVING SERVICE.*

BY HORACE L. PIPER,
Assistant General Superintendent of the Service.

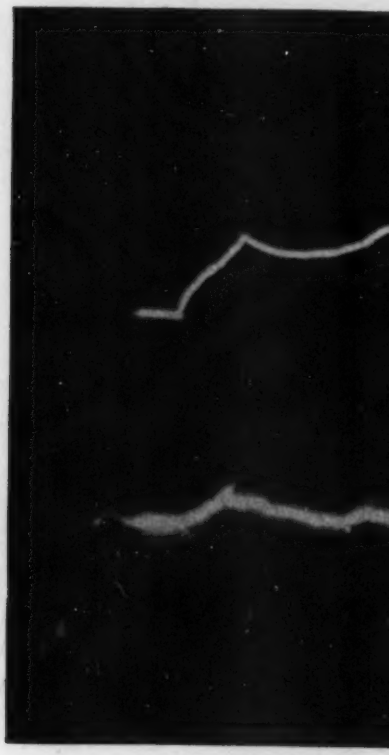
The preservation of life from shipwreck was not among the objects which early enlisted the interest of men. Even as commerce extended its scope the goods, not the sailors, were the objects of its solicitude. When the owner's right to his property was made to depend upon the fact that somebody should get ashore alive it became a matter of care to the plunderers on the coast that nobody should reach the shore alive, or if anybody did that he should straightway be put to death for his folly. To be sure, the coveted goods would not therefore lawfully belong to the wreckers, but "dead men tell no tales."

Although death in hideous form had long prior been denounced in England upon persons who, "more barbarous,

* A lecture delivered before the Franklin Institute.

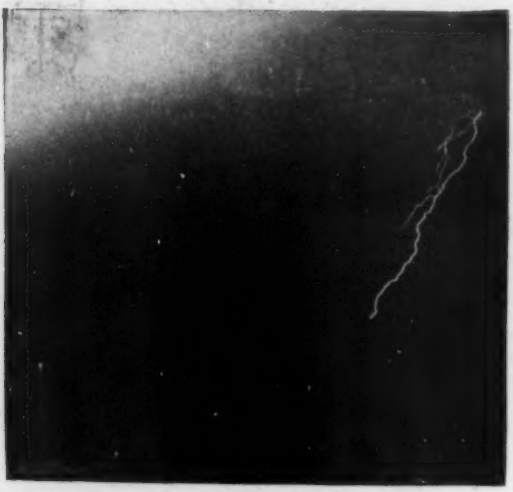


(1) Sketch of conventional "artist's" lightn

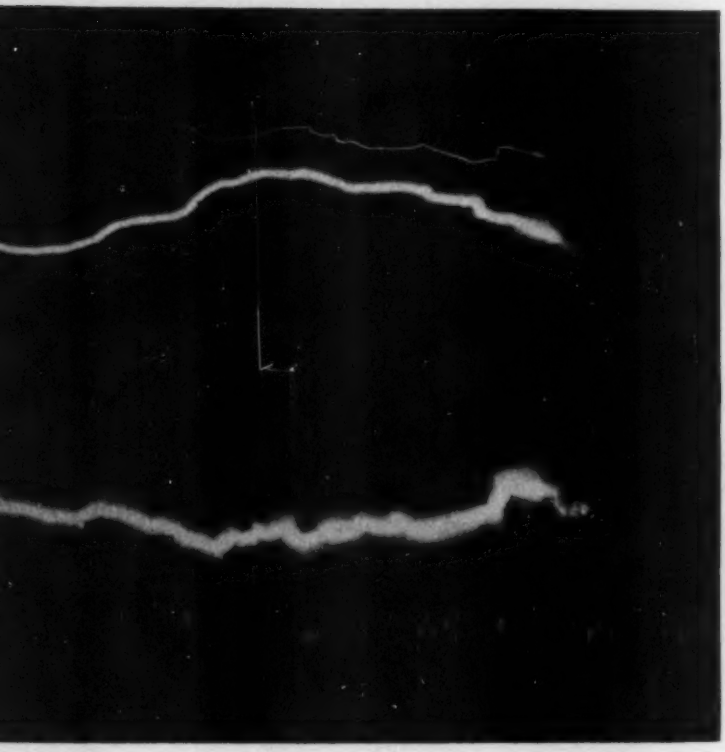


(2) Artificial

ist's" lightning.



(3) Wavy vertical discharge with branches.



(2) Artificial lightning. (Holtz machine sparks.)

VARIOUS FORMS OF LIGHTNING DISCHARGE. (Reproduced from photographs

cruel, and inhuman than mad dogs, murdered shipwrecked folk," the eighteenth century was well in its twilight before any organized effort, and that private, was made for the succor of such unhappy creatures. Our Declaration of Independence had been proclaimed and made good before such a thing as a life-boat had been conceived in England, where the first one was invented, and George Washington had been two years in our presidential chair when the first serious steps were taken in "the mother country" for the rescue of the shipwrecked.

The good people of the United States were no laggards in this great work. The year 1786 witnessed the organization in Massachusetts of the Humane Society of that commonwealth, which three years later formally dedicated its energies to the rescue and relief of castaways on that coast. So, it happily appears that a life-saving service of some sort, limited and imperfect it is true, began its career with the infant steps of the Republic. The Massachusetts society was the first organization of the kind in this country of which I have knowledge, and if it may not be called the parent of all others, it was at least the pioneer. Though already a centenarian, let us hope that it is still in the flower of youth.

The life-saving service of the United States had its inception in the year 1848, when Congress first made an appropriation for such an agency of the general government. It may be worth while to note the fact that this was also the year in which attention was re-awakened to the same subject in England, where it had languished to such an extent that a recognized authority declares the whole system to have been "in such a low state that in the entire kingdom there were perhaps not a dozen really efficient life-boats." But our appropriation of 1848 was only a beggarly pittance of $10,000, to be expended solely upon the coast of New Jersey. A few boat-houses were cheaply erected and equipped with this sum, but although small appropriations were subsequently made for additional houses and equipments at other points, no crews were employed until 1869, and then only at alternate stations.

While it might not be true to say that the service from 1848 to 1871 was discreditable, it certainly was not brilliant. Its new and glorious career began on the 20th of April, 1871, when Congress made an appropriation of $200,000 for life-saving purposes, to be expended by the Secretary of the Treasury through the medium of the Revenue Cutter Service, with which life-saving operations were then connected. The chief of the Revenue Cutter Service, at that time, was a young man who had only a few weeks before taken charge of the office, and who had himself suggested the appropriation mentioned, and devised a scheme for its judicious expenditure. The marvellous results achieved with this comparatively small sum, the record showing that on the coast of Long Island and New Jersey, to which the appropriation was limited, every life imperilled by shipwreck during the following season was saved, induced further favorable action by Congress, gradually enlarging the service, and finally by the act of June 18, 1878, organizing it into a separate bureau.

Mr. Sumner I. Kimball, the chief of the Revenue Cutter Service, to whom I have just referred, was nominated by the President, and without the usual reference to a committee, unanimously confirmed by the Senate to be General Superintendent of the new Life-saving Service. This remarkable tribute of confidence was not accidental—it was earned. During his administration of the Revenue Cutter Service, Mr. Kimball had raised its status from one of waning importance and efficiency to a very creditable footing, and at the same time had elevated the Life-saving Service to such a plane that it began to command general interest and confidence. His assumption of the new office was marked with vigor and enterprise.

DISTRICTS AND SUPERINTENDENTS.

Without undertaking to enumerate in full detail the various steps in organizing and perfecting the economy and morale of the service, let me proceed at once to submit, first, an outline of the organization as it now exists, and then as complete a *résumé* as possible within our limits of its operations.

The coasts of the Atlantic, Gulf of Mexico, Great Lakes and the Pacific—Alaska not included—comprising more than 10,000 miles, are divided into twelve life-saving districts, designated by number, beginning with Maine on the Atlantic, and terminating with Washington on the Pacific. The first district includes the coast of Maine and New Hampshire; the second, Massachusetts; the third, Rhode Island and Long Island; the fourth, New Jersey; the fifth, Delaware, Maryland and Virginia to Cape Charles; the sixth, Virginia and North Carolina from Cape Henry to Cape Fear; the seventh, South Carolina, Georgia and Eastern Florida; the eighth, the Gulf of Mexico; the ninth, Lakes Ontario and Erie; the tenth, Lakes Huron and Superior; the eleventh, Lake Michigan; and the twelfth, the Pacific Coast.

Each district is in charge of a superintendent, chosen for his knowledge of the subject, business capacity, and executive ability. He must be a resident of his district, of good repute, not less than twenty-five nor more than fifty-five years old when appointed, is required to understand the use of life-boats and life-saving appliances, and to be familiar with the lines and dangers of the coast under his guardianship. He is the disbursing officer of the district, under a bond ranging from $10,000 to $50,000 in amount, must visit every station once in three months, oftener when necessary, examine and test the crews as to drill and discipline, and has general supervision of the property, surfmen and operations.

The single-hearted devotion of many of these men to their noble work is a matter of well-deserved admiration. To them their vocation is much more than the mere holding of office with pecuniary reward. Nothing draws one so close to another as a kindred woe. Some of these men have themselves felt the clutch of the icy waters about them, and have been saved by only a little less than a miracle. In them the hoarse wail of the storm awakens the deepest emotions and the best impulses of human nature. Several have immortalized their names by acts of extraordinary heroism well worthy of recital here, but omitted for obvious

reasons. Some have made important inventions and improvements in life-saving appliances, and all are men of excellent reputation in their profession.

STATIONS AND THEIR LOCATIONS.

The districts are subdivided into stations, known by the names of their localities, and situated with regard to the special dangers of the coast. They are of two kinds: complete life-saving stations, and houses of refuge. The former have a building constructed of wood without much reference to architectural effect, but designed to withstand the tempest, and afford comfortable quarters for the surfmen and convenient rooms for the apparatus. On the first floor there are a boat-room, kitchen, keeper's office and sitting-room for the crew; on the second floor, the sleeping apartments. A lookout tower for the day-watch is placed upon the roof or near by, and there is a flag-staff for signalling, the service co-operating in this matter with the maritime associations of the country. A wreck-pole is also generally set up in the vicinity for the purpose of practice with the breeches-buoy apparatus. The equipments usually comprise two boats with outfits, a life-car, two sets of the breeches-buoy, a Lyle life-gun, cork jackets, heaving-sticks, night-signals, rockets, signal-flags, barometer, thermometer, necessary furniture, etc. Crews, generally consisting of six men and a keeper, are maintained during the active season —defined hereafter—the keeper being required to reside at the station the year round, unless granted an occasional short leave of absence during the inactive season, when a substitute must be furnished.

A house of refuge is provided with a frame house of sufficient capacity to accommodate as many persons as are likely to be cast on the adjacent shore, and furnished with the means of supplying their immediate wants. A small boat is supplied for the use of the keeper, but no crew is maintained. The keeper and his family reside in the house, and the beach is patrolled by them at such time as wrecks are likely to occur.

The whole number of stations of both kinds at the

present time is 240, several of them not yet fully completed and manned.

By far the greater part of our ocean commerce is on the Atlantic, and on that dangerous coast are located a majority of the stations. On the coast of Maine and New Hampshire there are ten; these shores, though rugged and stormy, having excellent and numerous harbors of refuge. The Humane Society of Massachusetts renders good service from the New Hampshire line to Race Point on Cape Cod, and therefore the United States provide protection for only a half-dozen especially dangerous points within those limits. In Mr. Kimball's address before the recent International Marine Conference, Cape Cod is aptly described as a narrow strip of sand, stretching directly out into the ocean some forty miles, then turning abruptly northward for an equal distance, like a threatening arm, its bars and beaches being the burial-ground of unnumbered craft. Here ten stations keep "watch and ward," at nearly equal distances apart, and well arranged to coöperate with one another. From the extremity of the Cape to Montauk Point there are nine.

White-winged messengers of commerce swarm along the coasts of Long Island and New Jersey as a multitude throngs the principal thoroughfare of a metropolis, and these shores are abundant with perils. On Long Island there are thirty-nine and on the New Jersey coast forty stations. From Cape Henlopen to Cape Charles seventeen treacherous points are guarded; from Cape Henry to Cape Hatteras—the sailors' traditional horror—twenty-three. On the coast of Florida, wrecks are usually cast well upon the land, the shipwrecked generally reaching the shore in safety, but sorely in need of temporary shelter and sustenance. Here are located the houses of refuge, ten in number besides one fully-equipped station at Jupiter Inlet, a point of considerable danger, about two-thirds of the way down the coast. The Gulf of Mexico has points of sufficient importance to call for eight complete stations.

Passing up to the Great Lakes we find five immense bodies of water with few natural harbors, and freighted with commerce of amazing proportions. Here the mariner

finds the dreaded lee-shore always under his forefoot. The extraordinary dangers of these land-locked waters furnish ample work for forty-nine crews. On the Pacific Coast, strandings are not frequent, the prevailing winds blowing along rather than upon the shore. To the present time twelve stations have been located there.

KEEPERS.

Every station is in charge of an officer who is really the captain of the crew, but is technically known as the keeper, that designation having been made in the early days when only one man was employed merely to keep the apparatus in order for the use of volunteers on occasions of wreck. The keeper is the person who directs the actual operations of life-saving. He decides upon all the movements, commands and steers the boat, and exercises absolute authority over the crew. There are difficult and fearfully important questions to be decided, and the decision must be made then and there, under the pressure of excitement, with human life trembling in the balance. Obviously this officer should be a man of skill in the surf, of sound discretion, of dauntless courage. He must be able-bodied, level-headed, and like Nelson, unacquainted with fear.

As in the case of superintendents, the selection of keepers is a matter of great moment to the service. They are generally nominated by the district superintendents, with a written statement of reasons upon which the nominations are based. If approved by the general superintendent, appointment follows. Keepers must not be under twenty-one nor over forty-five years of age upon entering the service, and are required, aside from the requisite qualifications of surfmen, to possess sufficient education to keep the records of the station, and conduct ordinary correspondence. Under this system an excellent body of men has been secured. Their record for courageous conduct in the face of extreme danger is without stain, but there have been some instances where a fatal error of judgment has required a keeper's removal. I recollect such a case (the error resulting in loss of life) where the

keeper distinguished himself by the display of remarkable courage on the very occasion of his failure, risking his life with reckless daring, and even suffering physical injury. The general superintendent was criticised for this removal as an act of unnecessary harshness, but his conclusive reply was that when human life is at stake, whatever may be second among the qualifications of a keeper, unquestionable sound judgment must be first.

The keepers of complete stations are generally paid $700 per annum. The Secretary of the Treasury may, under the law, allow a maximum of $800, but this sum is awarded only in cases where keepers have won special merit by the exhibition of superior courage and capacity. Keepers of houses of refuge receive $600 each per annum.

CREWS.

The crews are technically known as surfmen. Nobody need tell you what stuff they should be made of—the hazardous nature of their vocation tells that. Mere sailors will not do. Between the average sailor and a genuine surfman there is a wide difference; the former frequently, I might say generally, knowing little of surf-life. These crews must be surfmen, they must be the best, with muscles of steel and hearts of oak. They are selected by the keeper from the best men obtainable in the neighborhood, and must not be over forty-five years of age when originally enlisted. They are admitted only after rigid examination as to their physical and professional qualifications. They may not be discharged without good cause, and (with only two exceptions) not without special authority from the general superintendent. The exceptions noted are neglect of patrol duty and disobedience at a wreck, for either of which a keeper may dismiss a man on the spot. Happily these offences are of rare occurrence. Almost always the surfmen have displayed royal qualities crowned with dauntless courage. Their pay is $50 per month, during the active season only, and $3 for each occasion of service during the inactive season. From the meagre sums paid to keepers and surfmen, they must supply their own food and clothing.

That the rates of compensation are less than just is hardly an open question. At all events, as long as they prevail, the service may be considered safe from the assaults of unworthy seekers of soft places with fat salaries.

DISCIPLINE.

Here is a large corps of men, numerously subdivided and widely scattered, whose efficiency depends upon discipline; how is that secured? In the first place, the discipline of the crew devolves upon the keeper. He is required to keep a daily log or journal, in which must be noted all official transactions, including drill with the boat and practice with the beach apparatus. A transcript of the journal must be forwarded each week to the general superintendent at Washington, through the district superintendent. The keeper may generally be relied upon to report any serious infractions of the regulations, because, besides being required to do so, the maintenance of his own authority demands it.

But who is to maintain the watchful eye upon the keeper? Primarily he is under the charge of the district superintendent, who must make an inspection of all station affairs upon his quarterly visits, and render a report in writing to headquarters at Washington. There is also in each district, an assistant inspector—an officer of the Revenue Cutter Service, detailed for the duty—who is required to make a tour of the stations once every month during the active season; oftener if occasion should require. This officer drills the crew, examines them in their various duties, and is especially charged with matters looking to good order and discipline. He must also make a written report to headquarters at Washington. Then there is one general inspector of the service. Among a variety of other duties, he must make periodical inspection of all the districts, and file a report in detail at headquarters in Washington. Thus, it will be perceived, reports are constantly flowing from the branches to the centre of the service.

With a view to entire equity as far as possible, the general superintendent has not discouraged those whom I may

call the the privates in the ranks, from holding communication with himself, when they may feel that they should be heard directly without intervention. And yet all this would not make sure that condition of proper restraint and reasonable freedom essential to healthy *esprit de corps* if there were not at the head, an ungloved hand upon the helm. The dignity and authority of the officers must be maintained, the rights and self-respect of the men preserved. No failure of duty is excused except upon strong reason, after searching investigation. The grievance of the humblest surfman is inquired into, and rectified if well grounded, with all the care and impartiality which attend the treatment of a complaint preferred by the highest officer. The result is that discipline is good, and there is coëxistent with it, that feeling of restfulness and contentment among the men which is indispensable to a healthful and successful service.

OPERATIONS—BOATS.

On the Atlantic Coast the "active season" opens on the 1st of September and closes on the 30th of April; on the lakes, it opens and closes with the opening and closing of navigation; on the Pacific the stations are open and manned the entire year, disasters occurring there more frequently from local causes than from mere stress of weather, and being about as likely to happen at one season as another.

On the Atlantic, the 1st of September witnesses the muster of the crews. The men are told off by numbers, the presumably best surfman ranking as number one, next to the keeper, the others in regular numerical order according to known or supposed qualifications. The rules are read, and the house is set in order. Usually the members of the crew take turns in cooking, though they sometimes prefer to employ a cook. The domiciliary preparations having been completed, regular drill is begun, each day being set apart for a special purpose. The surf-boat or the life-boat is taken to the water, launched, and worked in the surf. Probably few who have ever gone out or come in through the breakers in a well-handled boat, have any ade-

quate idea of the danger. This operation involves the most difficult boat management known to the sea, even on an ordinarily calm day. When the ocean is disturbed by the storm, the waves are lifted in huge volumes many feet into the air as if by some great magnet, which suddenly loses its power, and they fall with a deafening roar, chasing each other in fury across the beach often to the high land. The boat must never be caught on the crest of one of these foaming billows, but must lag behind, or run before them. These are tricks to be played with a treacherous foe, and woe to him who makes a mistake. In such case the boat is either broached to and capsized, or lifted on end and toppled over, when the hapless crew must swim for their lives.

Nothing steadies a boatman's nerve so much as confidence in his craft. He must feel that she is agile and seaworthy, and will not play him false. In pursuit of these qualities the service has expended indefatigable industry. On the more important parts of our coasts, the English life-boat would be useless. It is a grand boat, and there clusters about it a glory of successful effort, which has made its very name honored and beloved, but its great weight restricts its use with us to exceptional localities. It weighs from two to four tons, is furnished with a heavy iron keel to secure the self-righting quality, and draws a good deal of water. Imagine seven or eight men on any of our flat beaches attempting to push one of these to deep water. Twenty men would exhaust their power and fail in the undertaking. Where these noble boats may be plunged at once into water of sufficient depth they are admirable, but for general purposes we have excellent models much less than half the weight of the lightest English life-boat, and possessing its best qualities. The Beebe-McLellan surf-boats are self-bailers, and as now equipped, readily righted if capsized. They are of light draft, easily launched and handled, and our crews have accomplished with them prodigies of surfmanship.

The Dobbins life-boat, although heavier, is still comparatively light, and well adapted to the demands of many of

our stations, where it has proved its efficiency. The same may be said of the Richardson life-boat. All three of these boats have been invented or adapted by the skill and intelligence of officers of the service. There are also in use at appropriate places a number of boats of the English model.

Surprise is sometimes manifested by persons unacquainted with the use of life- and surf-boats, that capsizes take place. It should be understood that no boat has yet been invented which may not be upset. If such were not the case, there would be no need of the self-righting quality, and a self-bailer furnished with air cases so that she could not sink, would make life-boat service little more than a matter of exhilarating pastime. But while a capsize is liable to occur at any moment, our service has been reasonably free from serious casualties in this way. During the existence of the present system there have been some sixteen cases including various types of boats, involving a loss of twenty-eight surfmen and fourteen shipwrecked people. During the same period, the English life-boat, which is selected for comparison, because heretofore supposed to possess every attainable best quality, has capsized twenty-one times, with a loss of sixty-eight boatmen and seven shipwrecked persons. When the number of times our boats have been in service and the number of persons involved are considered, the percentage of loss is perhaps as small as may ever be expected—certainly so until some now inconceivable invention has rendered a capsize next to, if not absolutely, impossible.

BREECHES-BUOY—LYLE-GUN—LIFE-CAR.

Boat drill alternates with practice in working the breeches-buoy apparatus. This device is like a pair of trunks or knee breeches made of canvas with a circular life-buoy for a waist belt, and is hung by four small ropes to a pulley running on a hawser. First, a small line about a quarter of an inch in diameter and very strong is thrown over the ship with the gun. This line is hauled on board by the sailors, having attached to its shore end an endless larger line called the whip, run through a pulley, to which

is attached a tally-board with directions for its adjustment on board printed in English and French. When the whip-line block reaches the vessel it is made fast by the sailors, well up on the mast if possible. The rest of the work is done by the life-savers. Hauling on one part of the whip, they send out a three-inch hawser, also bearing a tally-board with instructions that it be made fast just above the whip-line. The shore end of the hawser is anchored in the sand, and raised from the earth on a tripod or crotch. Then the breeches-buoy is swung to the hawser, fastened to the whip, and all is ready. By pulling on one part of the whip the buoy is sent out, and by reversing the action drawn back, each return generally bringing to the shore in safety one or two people. By this simple contrivance thousands of lives have been saved. Practice with this apparatus is conducted on shore with the wreck-pole, already referred to, serving as the mast of a disabled vessel. The life-gun is the invention of Capt. David A. Lyle, a distinguished officer of the Ordnance Corps of the United States Army, whose name it bears. It is composed of bronze, and with its line-carrying projectile, weighs a little over 200 pounds. It has a range, under the most favorable conditions, of nearly 700 yards, and has so far nobly met the requirements of the service.

The safety of the breeches-buoy as a means of rescue is well established by the fact that there is but a single instance on our records where a person once embarked in it has been lost.

The life-car now in use in our service embraces the essential features of the "Francis Metallic Life-Car," made famous some forty years ago by the rescue of a large number of people from the wreck of the *Ayrshire*, on the coast of New Jersey. The car of the life-saving service is constructed of metal in the shape of a boat, sharp at both ends and housed in. Access is had by way of a small hatch, which may be securely fastened either on the outside or inside, and the car may be drawn to and fro, either suspended on a hawser, or through the water. It is of sufficient capacity to accommodate several persons.

LOOKOUT—PATROL—TELEPHONE.

From sunrise to sunset the lookouts by turns keep their perch in the lookout tower, and when night approaches the patrols prepare for the lonely tramp along the shore. At any hour from night-fall to day-break, during the eight stormy months of the year, were you to find yourself on a beach protected by the life-saving service, you would be sure of meeting one friendly traveller to give you greeting.

The importance of this system of patrol at night—and by day in thick weather—cannot be overestimated. It makes sure that a wreck shall not come tumbling in, and be left undiscovered and helpless for hours when moments are precious, and delay is almost certain to result in unnecessary if not wholesale loss of life. By the patrol system a wreck is almost always discovered within an hour, generally in a few minutes.

The labor and hardship patrol duty imposes upon the surfmen are not likely to be fully appreciated until one is informed of the difficulties and dangers attending it. On some of our beaches the patrol is at all times compelled to wade for considerable portions of his beat through small streams and inlets, and when the tide is unusually high or the rivulets are swollen to formidable proportions, his duty is never without peril to his life. It not unfrequently happens that the way is lost, or the stress of circumstances compels a deviation from the usual course, when unseen and unknown dangers are encountered, such as bluffs and gullies, occasioning frequent injury by falling, etc.

The six members of the crew are divided into three reliefs of two men each, the first relief doing duty from sunset to eight o'clock—the men going in opposite directions—the second from eight to midnight, the third from midnight to 4 A.M., and the first again from 4 A.M. to sunrise, the order being so changed from day to day that the double duty of the first relief, as above indicated, shall not fall to the same individuals.

The patrolman is equipped with a lantern, a night signal or two, and a check. The lantern lights his way; the signal—something like a Roman-candle burning a brilliant red

light—is carried to warn off vessels standing into danger. During the last year 227 vessels were warned away and saved with many valuable lives by this simple beacon light. The check the patrolman carries to exchange with his fellow on the adjacent beat, each taking back as a voucher of his fidelity, the one received from the other. Sometimes, alas, the check is never exchanged. Darkness and tempest and pitfall with exhausted human energy have conquered the brave heart, and its pulsations have expired on the stormy pathway of duty. It is a perilous task to traverse those desolate shores for miles in weather which would deter us from the streets of Philadelphia, and I can imagine no sadder scene than that which has been witnessed more than once in our service, of a search party tenderly bearing back to the stricken station the body of a comrade fallen by the wayside, every man impressed with the knowledge that come what may another must complete the broken journey.

Pertinent to lookout and patrol duty, and very closely related to it, may be mentioned the system of telephonic connection now widely used in the service. Where the coasts are most dangerous the stations are most numerous, and therefore nearest together, enabling them if informed of a disaster to coöperate in the work of rescue. The telephone furnishes a ready means of communication by day or night, and without the necessity of special operators to use it. The admirable results obtained in this way may be illustrated by the fact that as many as three crews have thus been brought together for combined service within less than two hours from the discovery of a doomed vessel.

While this feature is perhaps the most important, it by no means comprehends the entire benefits of the telephone. Nothing exerts a stronger influence upon individuals and communities than contact and association with others. Ambition and competition are thus aroused. Precisely this effect has been produced upon the morale of the service by the introduction of the telephone. A few men set apart in an isolated position, without outside associations, generally develop a tendency to sluggishness and demoralization, but when the telephone informs a crew that their neighbors are

up and doing, out in a heavy surf, or at work on the beach, setting up the apparatus and landing a man in less than eight minutes—as is often done at drill—they are apt to conclude that they are just as capable as their enterprising comrades, and are generally not long in going to work to prove it. In this and similar obvious ways the telephone has proved an invaluable auxiliary to the efficiency of the service. To the present time, about one-half of the whole number of stations have been supplied with telephonic service. Extension is being made where feasible and desirable, as rapidly as circumstances admit.

WRECKS.

When a wreck is discovered at night, a signal is burned to inform the disabled vessel that succor is at hand, and the patrolman hastens to the station to give the alarm. Then there is hurrying to and fro. Every man is on duty. The beach apparatus is at all times stowed in the hand-cart in an orderly manner, having reference to the sequence of the use of the various parts. This apparatus consists of the gun for throwing the shot-line, the whip-line, hawser, sand-anchor, breeches-buoy, shovels, lanterns and implements necessary to set up the gear. The surf- or life-boat, with its equipments, is always mounted on the wagon, and everything is ready, as in the engine house of a city fire department, to proceed without delay to the scene of operations.

Although the stations are located at points where wrecks are most likely to occur, the actual disaster is often several miles away. If possible, horses are used to draw the boat, while the men harness themselves to the hand-cart, each man always taking the same relative position. The cart with its load weighs upwards of 1,500 pounds, and the journey is often a toilsome one, the sea frequently running across the entire beach to the sand dunes, commonly called the sea-wall, the men being then compelled to plod their way over a yielding surface, or seek a more solid road further to the rear. Sometimes the route leads through the forest, where a passage must be hewn with axes, so that the crew reaches the beach abreast the wreck in a condition

well nigh approaching exhaustion, while the battle with the sea is still to be fought.

Then comes the question of method—shall the boat be used or the life-line? Meantime the roaring, tumbling, eager waters are doing their deadly work. Whatever is to be done must be done quickly. Here is a situation which makes a blunder almost as bad as a crime. If practicable, and especially if the stranded vessel is likely to break up at once, the boat is tried. This is required to be done because it is the readiest method, and if successful results in saving many lives at once; but to launch a boat in the face of an angry surf is frequently beyond the compass of the utmost skill and resolution. However, no keeper is excusable for failing to make an effort unless it would be obviously and beyond dispute foolhardy, or is clearly unnecessary. In such cases the breeches-buoy or the life-car is employed. The success of these methods depends upon the possibility of getting a line to the ship, which must be done with the gun, unless, as rarely happens, one is sent ashore by a float from the wreck.

Usually the gun is capable of reaching the vessel, and when communication is once established with the shot-line the first and great problem in the use of the breeches-buoy or the car practically disappears. The lines and hawsers are of the finest quality, and seldom, almost never, break. These three methods, the boat, the breeches-buoy and the life-car comprise all the means of life-saving known and used in the world. When they have failed, hope may well give way to despair.

RESULTS.

Omitting anything like an exhaustive statement, let me submit a few figures epitomizing the great results accomplished by the present system. During the destructive tempest of September, 1889, three crews in the vicinity of Cape Henlopen rescued 194 persons from twenty-two stranded vessels, thirty-nine being landed by boats, 135 by the breeches-buoy, and twenty by the life-car, not a soul being lost. On the 3d of February, 1880, in a night of intense darkness, wild with sleet and snow, the entire crews

of four vessels were rescued upon the coast of New Jersey without the most trivial mishap. The appliances were set up and worked by the dim rays of ice-covered lanterns, under the most discouraging circumstances. It would be almost impossible to imagine better evidence than this of the usefulness of the daily drill to which I have already referred. During that year (1880), only nine persons were lost out of 1,980 imperilled. The smallest number lost in any other year was seventeen out of 3,950 imperilled. In the memorable March blizzard of that year (1888), fourteen sail vessels and two steamers were assisted near the Lewes, Del., breakwater, only two persons being lost. Four crews, thirty-two men, on the Delaware coast, served in the two years, 1888 and 1889, at sixty-five wrecks, rescuing 499 persons (an average of fifteen lives saved for each individual surfman).

Although the scope of a station's operations is usually limited to a few miles, much longer distances are sometimes made. Probably the most remarkable instance ever recorded occurred on the 18th of November, 1886. On the morning of that day, two ghostly figures, proving to be two vessels in distress, were discovered off the town of Marquette, on Lake Michigan. There was no life-saving station there, and the people of the vicinity devoted the entire day to every sort of effort to reach the forlorn mariners. Boats and steam tugs were tried, a mortar and life-line were invoked. All failed. With the departure of daylight a pall of horror and dismay enveloped the town. The nearest life-saving station was at Ship Canal on Lake Superior, 110 miles away. Faintly hoping, almost despairing, a telegram was sent stating the appalling facts. A special train was at once ordered at the nearest railway station to Ship Canal, and the crew and apparatus were hastily embarked in the midst of one of the heaviest snow storms of the year. Before midnight the life-savers reached the scene of disaster, and after eight hours of indomitable effort, safely landed the two entire crews, twenty-four persons. During that year out of 6,601 lives imperilled, only fifty-eight were lost.

From 1850 to 1870, there were lost on the Long Island and New Jersey coasts alone, 512 lives—an average of twenty-five per annum—while under the present system from 1871 to 1889, with a largely augmented commerce and corresponding increase of disasters, there were lost 119, an average of less than seven per annum, a reduction of eighty per cent. It may be stated also that the figures for the former period (no official record having been kept) are undoubtedly far short of the true aggregate, while, for the latter period, all disasters are included. Taking the scope of the entire service into account, the loss of life under the present system has been only a small fraction over one in 100.

To summarize the whole matter in a single statement, the entire loss on all the coasts of the United States under the present system since 1871 has been only thirty-eight in excess of the loss on the Long Island and New Jersey coasts alone during the preceding twenty years. Twenty-eight of these were wreckers, who rashly cast off the lines of the Life-saving Service already on board, and declined assistance until too late to be of any avail.

We have attended at 5,452 disasters, involving 46,383 lives, of which only 550 have been lost, including the twenty-eight unfortunate wreckers just mentioned, who were unquestionably the victims of their own folly. In addition to this grand total of lives preserved, we have saved and assisted to save property to the value of $89,337,179.

A NON-PARTISAN SERVICE.

It is assumed that the status and achievements of the Life-saving Service, even as imperfectly set forth in these remarks, must command general commendation, and I should be loth to close without naming the one factor, which perhaps more than any other in my opinion, has contributed to the splendid result. That is its non-partisanship.

In his annual report for 1880, the present general superintendent, urging the necessity of a statute to place the service on a non-political basis, recognized and sanctioned by the law of the land, made use of the following language:

"The last section of the proposed bill embodies the important provision that *the appointment and employment of all officers and crews of the Life-saving Service shall be made solely with reference to their fitness and without reference to their political or party affiliations.*

"Much has been said in previous reports of the service, upon the necessity of selecting its agents strictly upon grounds of professional qualification, entirely ignoring all considerations of party or creed, and everything, in fact, but the plain business in hand. The sober sense of every thinking person, will, it is believed, approve this line of conduct. The purpose for which the establishment is organized is simply to save life from wrecks, and, secondarily, property; and to most effectively carry out this purpose the service must not be conducted in the interest of any platform or doctrine. The Life-saving Service is eminently one of experts, and its agents must be the ablest trained professionals that can be secured.

"When the wrecked vessel is swept fore and aft by the winter seas, and haggard sailors and sobbing women and children are clinging to shroud and bulwark, the man who can best take out the life-boat through the breakers to their rescue, is the man of all men for this service, though he be a pagan. The gunner that can cast at the first fire the shot-line over the breaking deck when the stormy night is blackest, and there is nothing to guide his aim but the spot of light made by the ship's lantern in the rigging amidst the rending surf and overleaping spray, be will proclaimed, by the sufferers his wreck-craft brings to shore, the man this service demands, though every caucus on the coast denounce his politics. If a patient be in mortal danger, and to save his life a capital operation is to be performed, we send for the surgeon. We raise no question of creed or party—we want only the surgeon, and we want the best. When the wreck is beating into ruin on the lee shore, the case is equally one of life and death, and equally, to the exclusion of every other consideration, is the highest professional ability required.

"Limiting the consideration simply to politics, it may be

said that the required expert might be found in the ranks of the dominant party, and therefore chosen in the interests of that party. But the moment the principle of a political qualification is admitted, the selection, even from the party itself, is liable to be fatally influenced, because another object is introduced, namely, to reward some past political service, or to secure such service in the future, and the choice, as in the case of most political appointments, would then be made upon the recommendation of men of political prominence and aspirations in the locality of the position to be filled, in whom personal interest, the desire for party triumph, or the heat of party contest might bias the judgment or create the temptation to ignore or lower the professional standard, to palter with the facts of character and conduct, or to blink defect and incapacity, thus leading to the imposition upon the establishment of officers and surfmen in respect to their ability to control votes and carry elections, rather than to save human lives at shipwrecks. Such a rule, once put in operation, however good in intention, would end by supplanting superior agents with agents less good, or good for nothing.

"The effort to conduct the service without reference to such considerations has not been accomplished, it is needless to say, without serious difficulty. The success is only due to constant firmness on the part of the officers in its immediate charge, invariably supported, it is gratefully acknowledged, by superior official authority. But other men must succeed them, who, perhaps, unwarned by an official experience, may have less resolution, or entertain different convictions, or who may simply serve the policy of future administrations possessed with views of the entire compatibility of such a service with party politics. The time for such a change in the fortunes of the Life-saving Service may come, and in the stations trained surfmen may one by one give way to mere party hacks, perhaps even to the point of entire substitution. But if it does come—and this conviction it is desired to put on record—from that time the usefulness of the service will be on the wane. Its efficiency is coëxistent with its continuance in the hands of the best

surfmen, chosen only for their professional mastery of the methods it employs.

"The section of the bill referred to would erect the only solid barrier which can protect the service from the dreaded encroachment.

"When by statute there can be no question of the singleness of purpose of the service, the answer to those who would use it for other ends is made before they arrive. This provision of the bill is therefore earnestly recommended."

On the 4th of May, 1882, an Act of Congress embodying the provision urged in the above quotation, was approved by the President of the United States. It is the law; it has been faithfully observed, and as long as it continues to be the service must command public confidence and will succeed.

When a wreck is pounding on the rocks the business in hand is to save all on board; no inquiry is raised as to their nationality, color or politics. Neither does the service ask nor care whether the life savers are democrats or republicans, mugwumps or prohibitionists, orthodox or heretic, so that they are upright, brave and able surfmen. It is a non-partisan service; it is a humane service—sweet as charity, broad as humanity. Standing on this noble eminence, above the strife of party and creed, "like some tall cliff above the storm," standing, as it confessedly does, at the head of all similar institutions in the world, every American may love it, aid and defend it.

THE SUBNORMAL IN GRAPHICAL DYNAMICS.

BY IRVING P. CHURCH, Ithaca, N. Y.

Probably a large proportion, if not a majority, of students of applied mathematics are led to the appreciation of a law, principle, or relation, more easily by a graphic, than by an analytical, illustration or proof. Accordingly we find that most text-books of mechanics, in the presentation of the subject of the rectilinear motion of a "material point" (or "physical point"), among other modes of treatment employ graphical methods of showing the relations between any two or three of the four variables involved (viz: *distance*, *time*, *velocity* and *acceleration*), the values of two variables being plotted as abscissa and ordinate, to give points in a curve.

For instance, taking as an abscissa the distance (s) of the body (material point) from a fixed origin in its path, and as an ordinate the time (t) which has elapsed since the body passed that origin, we obtain a curve at the various points of which the co-tangents of the angles between the tangent lines and the axis of abscissas are proportional to the velocities (v) of the body in passing the corresponding points of its path; since

$$\frac{ds}{dt} = v. \tag{1}$$

Similarly, with the velocity (v) as ordinate, and the time (t) as abscissa, the tangent of the "tangential angle" varies as the acceleration (p) of the motion; since

$$\frac{dv}{dt} = p. \tag{2}$$

By eliminating dt from eqs. (1) and (2), we obtain the familiar relation

$$v\,dv = p\,ds. \tag{3}$$

While the conception of the velocity of a moving point at a certain instant is a comparatively simple one to the

student, that of its acceleration at the same instant is rather elusive and needs building up by a variety of modes of illustration in the case of a beginner in mechanics. Now the representation of the acceleration by the tangent of an angle is neither convenient nor impressive, in graphic illustration. A *length*, however, that can easily be constructed and scaled off, whose variation during the motion, even without actual construction and scaling, can be roughly followed by the eye, and whose *position* is identical with that of the resultant force, would seem a much more effective representative for the acceleration; since the acceleration is proportional to the resultant of all the forces acting on the body at any instant and a force is usually represented by a definite length having both magnitude and *position*.

It is the object of this brief article to present and illustrate a simple method of the writer's for the graphic construction of the acceleration at any point of the path of a material point, whose motion is rectilinear, when the velocity (v) is given as a function of the distance (s) of the body from an origin in its path; *i. e.*, when we have given a curve with s for abscissa and v as ordinate, whether plotted from an equation or from the results of experiment.

Construction.—In *Fig. 1* let O be the origin and OS the actual path of the body. Suppose a curve $A\ B\ C$ has been constructed whose (horizontal) ordinates (x) are proportional to the velocities (v) for the corresponding positions of the body. Thus denoting by n the scale-number (arbitrary constant) adopted in laying of these horizontal ordinates (*e. g.*, if six velocity units, or six feet per second, are represented by one foot of distance, $n = 6$) we have $v = nx$, and

$$x = \frac{v}{n};$$

and $dv = n\,dx$. We here suppose the body to have some initial velocity $c = nx_0$ on leaving (or passing) the origin O.

m being any point in the path of the body, draw the corresponding ordinate x to determine the point q in this "velocity-distance curve," as it may be called. A normal

drawn to the curve at q will intersect the axis OS (*i. e.*, the path of the body) in some point N. Then the acceleration (p) of the motion at m is $p = n^2 \times$ the distance $\overline{mN}$; *i. e.*, $p = n^2 \times$ the length of the subnormal, $= n^2 u$. That is to say,

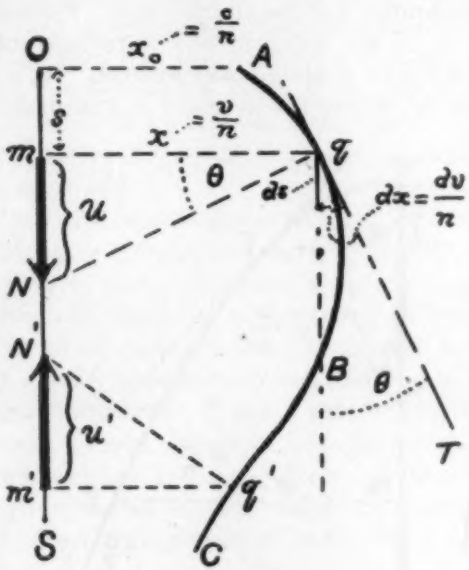


FIG. 1.

n being constant, *the acceleration is proportional to the subnormal of the "velocity-distance curve"* (coördinates being taken as in *Fig. 1*).

Proof.—If in eq. (3) above we substitute the values $v = nx$ and $dv = n\,dx$, we obtain

$$p = n^2 x \frac{dx}{ds}.$$

But, drawing through q the tangent line qT, and a right line qB parallel to OS; and also forming the elementary right triangle whose short sides are the increments ds and dx; we note that $dx \div ds = \tan\theta$; whence

$$p = n^2 x \tan\theta, = n^2 \times \overline{mN}, = n^2 u; \qquad (4)$$

(the angle TqB being $= mqN$, and the length of the subnormal mN being denoted by u).

If M is the mass of the material point or small body, the resultant force P at this instant has a value

$$P, = Mp, = Mn^2 u; \qquad (5)$$

this resultant force, therefore, as well as the acceleration, can be represented by the subnormal. Putting, then, an arrow-head at N we have in mN a representative of the resultant force, *both in amount and position.* At a point of the path, such as m', where the velocity is diminishing, the sub-

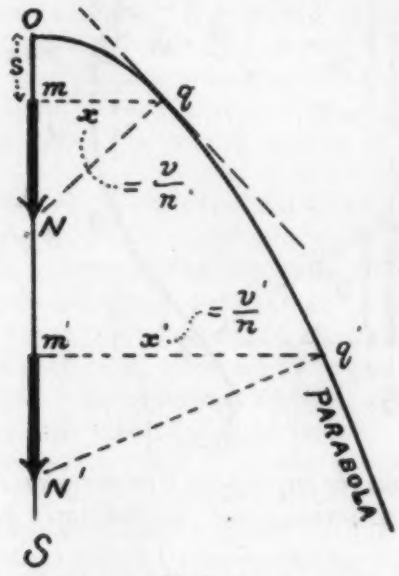


FIG. 2.

normal is negative, mN', as shown in *Fig. 1;* and correspondingly the resultant force is also negative (*i. e.*, a retarding force).

The advantage, then, of this construction is that we obtain at any point m of the path a measure of the acceleration, and also of the accelerating force (resultant), in the form of an arrow of a proper length, and *also of a proper position*, to represent that force as applied to the body at m. Even if the ordinates and normals are not actually drawn, in glancing along the curve the eye can judge approximately as to the variation of the accelerating force by estimating the

magnitudes and positions of the successive subnormals. The following applications will be made:

(1) *Free Fall in Vacuo.—Fig. 2.* In this familiar case of motion, since the resultant force is constant, we know the acceleration to be the same or constant at all points, *i. e.*, equal to g, that of gravity. From mechanics we have for this case, $v^2 = 2gs$; *i. e.*, the "velocity-distance curve" is a parabola; as it ought to be, since from analytics we know that the subnormal of a parabola is constant. That is, at m we find a subnormal u equal to that, u', obtained at any other point, as at m'.

(2) For a *uniform motion* along OS (*i. e.*, velocity constant) the curve becomes a right line parallel to the axis or path OS, and evidently the subnormal is zero at all points, as should be the case, since the accelerating or resultant force must be zero at all points if the velocity is not to change.

(3) If the *velocity is to increase in direct proportion to the distance* s of the body from O, the "velocity-distance curve" again becomes a right line, not parallel to the path, however, but intersecting it in O. Here, obviously, from the law of change of the subnormal, an accelerating force must be provided directly proportional to the distance s and having the *same sign.*

(4) *Harmonic Motion.*—(As is well known, the motion of the piston of a steam engine having a massive fly wheel and a long connecting rod is very nearly harmonic.) The principal property of this periodic, oscillatory, rectilinear motion is that the acceleration is proportional (but of *opposite sign*) to the "displacement" or distance (s) from the middle O of the oscillation.

In *Fig. 3* let O be the middle of the oscillation, D and C the extreme points. Denote OD, $= CD$, by r, and the velocity of the body each time it passes O (either up or down) by c. Let m be any position of the body going down. The circle (since all normals pass through the centre) is a curve in which the subnormal is evidently identical with the abscissa (except that it is of *contrary sign*) and hence proportional to it; of course, the origin being at the centre. Hence it is immediately apparent, from the above property

of harmonic motion, that if a circle be described with O as a centre and radius equal to r, it will be a "velocity-distance curve" for the harmonic motion; with a scale-number $n = c \div r$, since the radius $OE\ (= OD = r)$ is to represent the velocity c.

(An ellipse, also, would serve as a velocity-distance curve, the subnormal being proportional to, though not coinciding with, the abscissa, and of opposite sign; but,

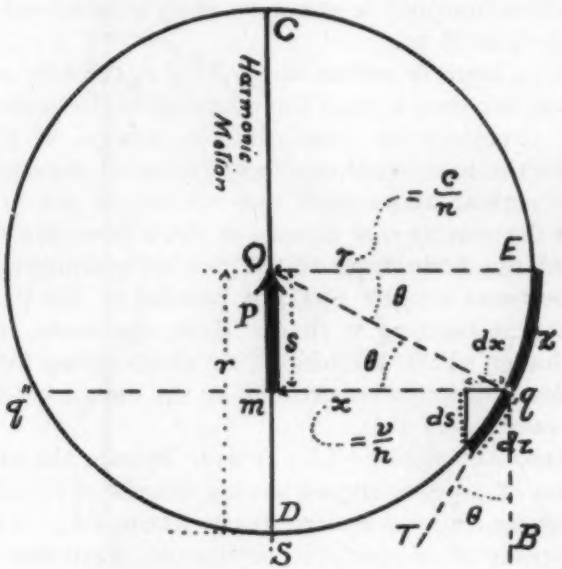


FIG. 3.

aside from its simplicity of construction, the circle has a peculiar advantage, as will be seen, in representing the *time* of reaching any point.)

The above circle being drawn, the subnormal u for any point m of the path, is equal to the abscissa s with its sign changed, whence the acceleration is

$$p = n^2 u = n^2 \times \overline{Om} = -n^2 s, = n^2 r \sin\theta = \frac{c^2}{r} \sin\theta$$

while the velocity at m is

$$v = n x = \frac{c}{r} x \left(\text{so that } av = \frac{cdx}{r}\right)$$

(The left-hand half of the circle pertains to the upward return motion.) In this case we find the peculiar feature that the *time* (t) occupied by the body in passing from O to any point m is proportional to the length of curve z from E to q, which is proved as follows:

Inserting the above values of p and dv in the fundamental relation—

$$p = \frac{dv}{dt},$$

there results

$$dt = \frac{dx}{\sin\theta} \cdot \frac{1}{c} = \frac{dz}{c},$$

where dz is the hypothenuse of this elementary right triangle at q. But this gives

$$\frac{dz}{dt} = c. \tag{6}$$

That is, the velocity ($dz \div dt$) of a point q imagined to move along the curve from E and always keeping in the horizontal through the material point m as the latter moves along $O \ldots S$, is *constant*, $= c$. Hence the time (t) occupied by the body in passing from O to any other point m of its path must be the same as that necessary for the imaginary point q to describe the linear arc $E \ldots q, = z$, with a *constant velocity* $= c$; therefore the time $t = (lin\ arc\ Eq) \div c$. For instance, the time of passage from O to the extreme point D is

$$t_D = \left(\frac{\pi r}{2}\right) \div c = \frac{\pi}{2} \cdot \frac{r}{c};$$

so that for a complete cycle or period the time

$$= \frac{2\pi r}{c}.$$

Also, to pass from O to D and up again to m, requires a time

$$= \frac{lin\ arc\ E\ D\ q''}{c}.$$

Evidently, to secure this motion, the body having the initial velocity c at O, the resultant force must always point

toward O and be caused to vary in proportion to the displacement s; its absolute value at D, *e. g.*, being

$$P_D = Mn^2 u_D = Mn^2 r = \frac{Mc^2}{r}.$$

That is, at any point m it must have a value

$$P = Mn^2 u = \frac{Mc^2}{r^2} \cdot \frac{s}{r}.$$

(5) *Free Fall with Air-resistance.*—As an example where a practical application can be made of the foregoing property

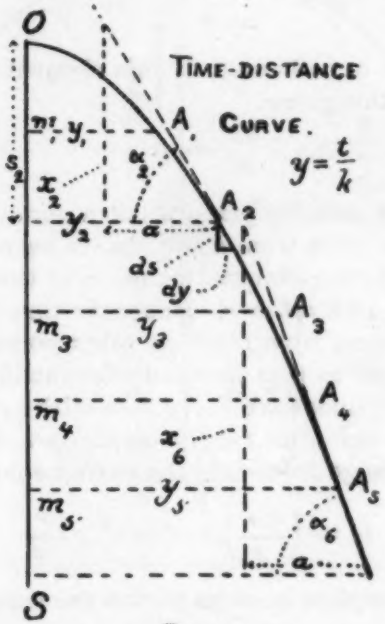


FIG. 4.

of the subnormal in a velocity-distance curve, let us suppose that experiments have been made in the laboratory (with a tuning-fork chronograph, electric signals, etc.), with the vertical free fall, in the atmosphere, of a body of such comparatively large bulk and small mass as to meet with considerable resistance from the air; and that it is desired, by means of the measured times of reaching six successive points in the vertical path, to determine graphically the resistance of

the air at each point, and hence the dependence of this resistance on the velocity. The body having started from rest at O, *Fig. 4*, let s_1, s_2, s_3, etc., be the respective distances from O of the six points, m_1, m_2, m_3, etc., and t_1, t_2, etc., the observed times (all reckoned from the instant of leaving O). Selecting a convenient scale-number k for the times (*e. g.*, with the foot and second, $k = 5$ signifies that one foot of ordinate represents five seconds of time) plot the six horizontal ordinates $y = t_1 \div k$, $y_2 = t_2 \div k$, etc.; (in general $ky = t$ and

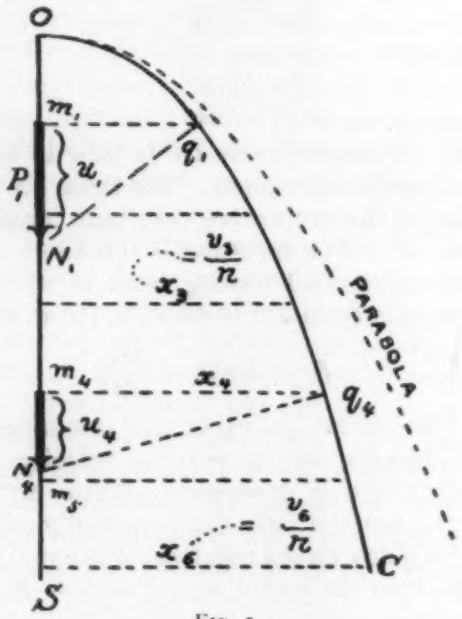


FIG. 5.

$dt = k\,dy$). Through O and the six points last determined, and A_1, A_2, etc., draw carefully a smooth curve, and at each of the six points a tangent line; and also from each point lay off to the left, along the ordinate, a convenient distance a, the same for all, through whose left-hand extremity draw a parallel to $O \ldots S$ to meet the corresponding tangent line and thus determine six vertical distances x_1, x_2, etc., proportional to the velocities of the body as it passed the respective points m_1, m_2, etc.

(For in general, at any point, of this "time-distance curve," we have

$$x = a \tan \alpha = a \cdot \frac{ds}{dy} = ak \frac{ds}{dt} = a k v).$$

With the same points m as before on the axis $O \ldots S$, now plot the successive x's as horizontal ordinates (*Fig. 5*) and thus obtain points q_1, q_2, etc., on a "velocity-distance curve" OC (since these x's are proportional to the velocities; the scale-number implied in their use as ordinates being

$$n = \frac{1}{ak};$$

for nx $(= v)$ must

$$= \frac{x}{ak}$$

from above). A smooth curve OC is now to be drawn and the six subnormals constructed. The latter are proportional to the values of the respective resultant forces at the six points m_1, m_2, etc. For instance, if u is the length (in feet, say; the foot and second having been in use) of the subnormal for m_1, the resultant force at m_1 [from eq. (5)] is

$$P_1 = Mn^2 u_1 = \frac{Mu_1}{a^2 k^2}.$$

At each lower point the value of P is smaller, as the air-resistance increases with increasing velocity. Since the body's weight G acting downward, and the air-resistance R acting upward, are the only forces actually exerted on the body the (ideal) downward resultant P is equal to the excess of the former over the latter, *i. e.*, $P = G - R$; whence we have, at any point m,

$$R = G - \frac{Mu}{a^2 k^2}. \qquad (7)$$

As to the dependence of the air-resistance R on some definite power of the velocity, further computations or graphic operations can be undertaken in an obvious manner.

Fig. 5 also shows (dotted) the parabola, or curve of constant subnormal, which would be obtained as the velocity-distance curve corresponding to a free fall in vacuo (plotted with the same value of n).

THE PORT OF PHILADELPHIA.

BY PROF. LEWIS M. HAUPT, C. E., University of Pennsylvania.

[*A lecture delivered before the Franklin Institute, November 20, 1891.*]

Some cities, like some men, are born great, while others have greatness thrust upon them.

Philadelphia was destined to attain greatness from her infancy. Her founders were not mere adventurers, but men of firm religious convictions, who found on the shores of the majestic Delaware a refuge from persecution. Here the intrepid Swede, the adventurous Dane, the philosophic German and the conscientious Quaker dwelt together in brotherly love.

The site of the city was carefully selected by William Penn, with reference to its adaptability to the wants of a large community. Its facility of access by the means then available, its harbor, its topography, its sources of supply of food, water and fuel, fish, game and timber, were all duly considered, and so wisely was the site chosen that for 144 years Philadelphia maintained her supremacy over all the cities of the new world. Her ships covered the seas, her "conestogas" traversed the mountains, her manufactures supplied the most distant markets, while her intelligence and public-spirited patriotism made her the cynosure of the world.

In 1820, five years prior to the opening of the Erie Canal, Philadelphia had a population of 135,673, being 11,931 more than that of New York. In 1830, five years after the opening, there was a balance of 8,325 in favor of New York, and this difference has been constantly increasing to date. In 1840 it was 54,673 more; in 1850, 106,785; in 1860, 248,140; in 1870, 268,270; in 1880, 359,039 and in 1890, 468,649, showing a rapid rate of increase.

The city of Chicago was chartered in 1837, with 4,170 inhabitants. At the date of the last census its population

was 1,098,576, or 53,682 more than that of Philadelphia. Thus, in a half century this interior port has outstripped her two-century-old sister.

The opening of the Erie Canal caused a decline in the commerce of Philadelphia, while it greatly stimulated that of New York, since it increased immensely the territory tributary to that centre. It did not violate the general law relative to the location of the proper site for our city, viz: at the point of transfer between land and water carriage, or at the head of navigation, but it modified the conditions and enabled both New York and Chicago to surpass us, in consequence of their terminal positions, on a line of less resistance, reaching a larger territory.

The reason for the locus of transfer being found at the head of navigation for ocean vessels, will become apparent upon a moment's reflection. While land and water traffic are reciprocal, it must be remembered that the water produces comparatively nothing while the cost of movement over it is much less than that on land. Hence the more land there is surrounding a navigable channel to the sea, the greater will be the commerce. A city on the border of an extended and straight coast-line, as Norfolk, for instance, will have but a semi-circular area to draw from; one which is on a reëntrant angle, like New York, will have three-fourths of the circle tributary to her port; while one that is in the heart of a continent, as Chicago, will have nearly the full circle, and hence for equal land rates of transportation and an equivalent population, the latter will have a great advantage as a shipping point. If there were a deep draught channel from Chicago to the sea, whereby the break of bulk at Buffalo and New York might be avoided, the water rate would be still lower, and the advantage of the terminals be even greater.

Substantially the same conditions exist at Superior and Duluth since the enlargement of the Sault St. Mary Canal, excepting that a portion of the tributary area is on foreign territory. Thus the geographical position of the port is seen to be an important factor in determining the amount of its commerce, but there are other elements which mate-

rially affect this movement. One of these is the cost of land transportation. This is a function of the number and character of the ways of communication. The more railroads and highways there are radiating from the port, the lower will be the tariff, provided the roads and rolling stock are maintained in good condition as competing lines. In this particular New York and Chicago outstrip Philadelphia in about the ratio of six to one.

Cheap transportation to and from the back country is therefore another of the ruling factors in determining the amount of commerce of a port, since it expands or contracts the tributary areas inversely as the square of the rate fluctuates.

It behooves us, therefore, as citizens, to consider whether it is not possible to extend the tributary territory of this point by reducing the rate of traffic or by increasing our facilities for reaching a much larger constituency, for patronage is the life of trade, and the transportation lines are the tentacles whereby this life is maintained.

The transportation routes tributary to Philadelphia are the lines owned, controlled, leased or operated by the Pennsylvania Railroad Company, which embrace (1890):

	First Track. Miles.
The United Railroads of New Jersey,	445·69
New York and Long Branch Railroad,	38·04
Pennsylvania Railroad (Main Line),	1,441·37
Philadelphia and Erie,	549·31
Northern Central,	382·45
Junction Railroad in Philadelphia,	3·56
Philadelphia, Wilmington and Baltimore,	648·08
New York, Philadelphia and Norfolk,	111·46
West Jersey,	222·01
Camden and Atlantic,	80·49
Cumberland Valley,	164·74
Allegheny Valley,	259·40
	4,346·60
Total trackage in Pennsylvania, including sidings, etc.,	8,288·14

In addition to this there are the following lines under the jurisdiction of the "Pennsylvania Company," having its

headquarters at Pittsburgh, and coöperating with the Pennsylvania Railroad:

	Miles.	
The Pittsburgh, Fort Wayne and Chicago,	469·9	
Branches,	352·4	
Leased lines,	338·9	
		1,161·2
Operated by control of stocks:		
Pittsburgh, Cincinnati, Chicago and St. Louis,	1,144·5	
Its branches,	247·7	
Other lines,	445·9	
		1,838·1
By guarantees of Pennsylvania Railroad Company,		491·1
		3,490·4
Mileage of Pennsylvania Railroad brought forward,		4,346·6
Total mileage under control of Pennsylvania Railroad,		7,837·0

The Philadelphia and Reading system embraces under its control a total of 1,106·6 miles, and carried in 1890, of coal, 10,821,691 gross tons; of miscellaneous freight, 10,968,536 gross tons: and, including the weight of passengers, a total of 24,788,527 tons, the number of passengers being 18,103,893.

The Lehigh Valley Railroad Company's lines connecting Lake Ontario at Fairhaven with New York and Philadelphia, cover a distance of 886·24 miles. This company's business is reported for 1890 to have been:

Passengers,	5,191,821
Miscellaneous freight (gross tons),	5,358,064
Coal,	9,101,824

The Lehigh Coal and Navigation Company have, of railroads (leased to Central Railroad of New Jersey), 192·49 miles; of canals (leased to Central Railroad of New Jersey), 108 miles.

The Baltimore and Onio Railroad embraces:

	Miles.
Main Line to Wheeling	379·80
Branches of Main Line,	391·15
Philadelphia Division,	124·00
Pittsburgh Division,	335·60
New York Division,	5·05
Trans-Ohio,	647·58
Valley Railroad of Virginia,	62·00
Ohio River Bridge,	2·50
	1,948·13

It connects Chicago, Cleveland, Sandusky and Cincinnati with Baltimore, Philadelphia and New York. On the 1,212 miles east of the Ohio it carried, in 1890, 11,469,091 passengers and 25,652,284 tons of freight. Of these 2,529,335 passengers and 5,882,289 tons were moved over the Philadelphia Division.

Thus while the mileage of these four trunk lines aggregates 11,970 miles, it does not mean that it is all tributary to Philadelphia. On the contrary it is divided mainly between New York, Philadelphia and Baltimore as well as its western terminals, and the percentage of traffic going to each is determined largely by the local facilities, rates, demand, policy and interests of the transporting companies. That the *pro rata* coming to Philadelphia is small, will be evident from her commercial statistics as compared with those of the other Atlantic ports.

Thus the value of the exports of breadstuffs, provisions and mineral oils for the year ending June 30, 1891, are reported as follows, from

	New York	Baltimore.	Boston.	Philadelphia.
	$109,825,000	$40,544,000	$28,014 000	$19,865,000
Ratio,	5·5	2	1·4	1

From which it appears that, while Philadelphia is as near to the sources of these staples as any of the four ports on the Atlantic, she cannot compete even with so distant a point as Boston, which shipped more than three times the quantity of breadstuffs and provisions that Philadelphia did.

As the New England States are not producers of these articles, but consumers, the bulk of the freights originating in the West must have gone by water past New York and up the Sound to Boston before it could be exported. The opening of the Cape Cod Canal will still further stimulate this trade and make the discrepancy of our local exports even greater, unless measures are taken to counteract this influence.

Again, if we compare the *total exports* of the four ports we will find Philadelphia far in the rear. For 1890 the exports from New York, Boston, Philadelphia and Baltimore, were:

	New York.	Baltimore.	Boston.	Philadelphia.
Foreign, ...	$15,845,974	$22,941	$836,989	$170,863
Domestic, ...	370,322,430	73,967,796	70,364,955	37,241,645
Total exports, . . .	$ 86,168,404	$73,990,737	$71 201,954	$37,412,508
Ratios referred to Phila.,	10·3	1·99	1·9	1

In 1887 these relations were 10, 1·5, 1·7, 1; in other words, the export trade of Baltimore and Boston have increased more rapidly than that of Philadelphia and are actually nearly double that of this city, although the population of either of those places is less than half that of this port.

May we not inquire, of what avail is it to be the largest manufacturing centre in the United States and what becomes of our products? Are they sent to other ports for shipment, thus increasing their cost to the consumer or adding to the expense of the producer? As well might we expect freight to be hauled by rail from Baltimore to Philadelphia to be shipped, as from Philadelphia to New York for the same purpose. The great discrepancy between New York and Philadelphia is certainly not due to differences in population, nor in manufactures, nor to geographical position, nor to relative proximity to the source of the great staples composing the bulk of the commerce, coal, wheat, oil, sugar and textiles, for in these respects the two cities are far within the limits of their commercial ratio of of one to ten.

No matter in what direction we look for the cause of this great discrepancy, we are forced to the conviction that for some inexplicable reason the "common carriers" find it subservient to certain interests to deliver the bulk of their freights at other terminals than those on the Delaware; for there is no mechanical or physical law that will justify a movement over a line of greater resistance rather than over

the lesser one, provided it have equal facilities for storage and trans-shipment.

This general statement is confirmed by a glance at the statistics of the *grain exports* of New York, Baltimore, Boston and Philadelphia for the past few years.

Exports of wheat and corn from

	New York.	Baltimore.	Boston.	Philade'phia.
1887, ...	54,192,321	18,175,104	6,297,883	10,770,757
1888, ...	26,845,423	7,824,422	4,456,486	1,809,215
1889, ...	39,571,280	21,212,598	7,595,044	4,750,922
1890, ...	37,163,433	24,250,597	5,025,990	17,353,397

The logic of these figures shows that in 1888 and 1889 this port shipped barely one-half as much wheat and corn as Boston, seventy-eight per cent. less than Baltimore and only one-eleventh that of New York, yet this was not due to any differential rates favoring the more remote ports, for the following were the tariffs as published for 1889,* all rail, from Chicago to

	New York	Phila.	Balto.	Boston.	To Liverpool. Average.	Cwt.	Chicago & Lake Erie Canal Charges to New York (including Buffalo.)
Flour, per barrel, . . .	50	46	44	60	—	—	
Grain per 100 lbs., . .	25	23	22	30	39½	12 5-6	7 5-7 cts. per bu. (60 lbs.)
Provisions per 100 bbls.,	30	28	27	35	57½	—	
Corn per 100 lbs., . . .	20	18	17	25	—	—	

Showing that it cost four cents more per pound for flour by rail to New York, and sixteen cents more to Boston than to this city. For grain the differences are also in our favor, viz: two cents per hundredweight to New York, and seven cents to Boston. Hence, if there were no disturbing

* *Thirty second Annual Report, Trade and Commerce of Chicago.*

causes, the law of distribution over the lines of least resistance, as measured by the cost of movement, should bring the bulk of the grain to Baltimore and Philadelphia, rather than to New York and Boston. But when it is seen that the through rate by the lakes and the Erie canal, including the Buffalo charges, is only *one-half* the all-rail rates to New York it explains the anomaly, and shows why even Boston can export more than Philadelphia, and it forcibly points the moral as to the importance of maintaining the waterways for the public welfare. I have frequently urged the importance to Philadelphia of a more direct and enlarged artificial channel between this city and New York, by way of the Upper Delaware River, and the Delaware and Raritan Canal, thus extending the benefits derived from the Erie Canal to Philadelphia, and rendering it possible to bring that powerful auxiliary into competition with our railroads for the interior traffic of the country. Even should the traffic not be large over the canal, the facilities would be there and the moral effect would be to keep rates low and greatly to augment the business. I believe this one project would have a greater beneficial effect on the commerce of this entire section of country than the building of half-a-dozen trunk lines of railroad. There is no part of the civilized world where such a canal is more greatly needed, or where it would give greater promise of success. Its termini would connect a population equal to one-tenth that of the entire United States, and as I have elsewhere proven,* it would be beneficial to the railroads skirting its territory. No other canal across New Jersey would pay in competition with the river as it would take too long to pass through it.

But the low water rates *via* the Erie Canal are not alone responsible for the decadence of this port. A few statistics relative to the movement of *grain cars* will also be found suggestive. Thus the car receipts for 1890, at New York, were as follows:

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* Pamphlet, *The Commercial Paradox*, from *The Manufacturer*. By L. M. Haupt, Philadelphia.

	N.Y.C.	W. Shore.	Erie.	P.R.R.	D.L.&W.	L.V.R.R	Total.
1890, ...	8,866	15,105	19 782	3,545	4,226	11,628	63,152
1891 to October 16th, ...	23.618	16,601	22,272	1,833	1,157	9,697	75,178

Thus the New York Central and West Shore, although longer than the Erie, moved, up to October 16th of this year, 40,219 cars, as compared with 22,272 over the Erie, and only 1,833 over the Pennsylvania Railroad. The business of the Lehigh Valley road in grain to New York is, by this exhibit, five times greater than that of the Pennsylvania Railroad.

The data for Philadelphia and Baltimore are:

	Cars Moved to Philadelphia.			To Baltimore.		
	P. R. R.	P. & R.	Total.	P. R. R.	B. & O.	Total.
1890, ...	18,276	9,492	27,768	17,662	17,495	35,157
to October 16, 1891, .	6,138	5,068	11,206	10,672	12,248	22,920
Total loss, ...			16,562	Total, ...		12,237

This shows a remarkable falling off in the grain movements to date for both of these ports. The Pennsylvania Railroad has 12,138 cars less for Philadelphia to date, October 16, 1891, than it had for the whole of last year, and 6,990 less for Baltimore. The Philadelphia and Reading Railroad has 4,434 cars less for this point, and the Baltimore and Ohio 5,247 less for Baltimore. The total losses are 16,562 cars for Philadelphia, and 12,237 for Baltimore, or for both places, 28,799 cars. The gain in New York has been 12,026 cars, and it is worthy of note that by far the largest gain on any of the railroads was that on the New York Central and West Shore (16,248 cars), and which *parallels the canal and Hudson River.* Surely this waterway does not appear to have injured these railroads. Why so large a percentage of the grain movement should have taken the longer northern route, and the business of the lines leading to these nearer terminals should have so greatly fallen

off in this year of plenty, must be left, for the present, largely to conjecture. It is sufficient to state the facts: Thus from January 1st to October 2d, the exports of wheat and corn from Philadelphia amounted to 5,856,286 bushels as compared with 17,110,154 bushels for the same period of last year, a loss of 11,253,868 bushels,* or 337,616 tons. For Baltimore the figures for this year are 13,610,706 bushels, as compared with 23,526,908 for last year, being a loss of 9,916,202, which is not quite so great a reduction as here. While for New York the exports of wheat and corn for the nine months ending October 2, 1890 and 1891, were 32,658,859 and 36,163,427 bushels, respectively, being a gain of 3,504,568 bushels. New York's percentage for this period of 1891 was 47; Baltimore's, 18; New Orleans', 11; Montreal's, 9; Philadelphia's, 7, and the balance scattering. In 1890 our proportion of this trade was sixteen per cent. From whatever standpoint we view the commercial statistics, therefore, we find Philadelphia occupying the lowest position amongst her rival ports.

THE PETROLEUM MOVEMENT.

Let us look for a moment at another of the staple exports of the country which to-day is practically independent of any of the laws of competition in transportation. I refer to petroleum. There are pipe lines under the same management reaching from the oil centre to each of the three ports, New York, Philadelphia and Baltimore, and although the line to the last-named point is perhaps a little shorter than either of the others, the cost of transportation is virtually the same, hence the amount of exports may be taken as furnishing some indication of the relative importance of the port facilities for foreign exports.

The shipments for 1890, were, from New York, 8,871,059 barrels; Philadelphia, 3,185,924 barrels; Baltimore, 288,643 barrels. Total, 12,335,626 barrels, of which the percentages were: New York, 71·92; Philadelphia, 25·82; Baltimore,

* "The loading capacity of the 60,000-pound car varies from 850 to 900 bushels for wheat; from 850 to 1,000 bushels for corn, and from 1,200 to 1,500 bushels for oats." Average increase, oats, 1,050.

2·26, but so great were the facilities offered for the product at this port that a new line was put into operation here, February 27, 1891, and the percentage of oil sent out has now risen to 33·67, while that of New York has fallen to 64·51, and of Baltimore to 1·82.

These figures would seem to justify a much higher rank to this port than is generally accorded her on the commercial registers, and go far towards showing that the decadence of the commerce is not due so much to physical obstructions to navigation nor to geographical position, as to the manner in which the freight movements are regulated by those having control of them. For the lake and rail traffic Philadelphia has advantages not possessed by any other port, since, from Erie, the rail distance is but 446, while to New York from Buffalo *via* the New York Central is 442 miles, and by the Erie Railroad it is 423 miles. From Erie to Baltimore is 426 miles or only 20 miles less than to Philadelphia, but the former is much further from the sea than the latter, and hence the desire for a ship canal across the Peninsula to Delaware Bay. Erie is also nearer the source of freight than Buffalo and has a more capacious harbor.

In this connection one of the most experienced observers in the United States says:*

"The city of Philadelphia has superior internal communications with the entire country lying west of her boundaries. The traffic produced and exported to foreign countries by that large area of territory, and that which it imports, can, so far as promptness and cheapness of transportation are concerned, be better done through Philadelphia than through any other Atlantic port, because the Delaware River permits the water portion of the through carriage to continue so much further inland than any other port having equal rail and lake connections with the great West."

The superiority of the site is indisputable, and has been demonstrated by experience, but, as has been shown, the conditions of trade are unfavorable, and Philadelphia ranks

* Col. Jos. D. Potts.

among the least of the principal commercial centres of the country. The existence or non-existence of the islands in the Delaware, about which so much has been said, is a comparatively unimportant factor in the case. Their removal, which is estimated to cost $3,500,000, will not change the policy of the transportation companies towards this city. It will, however, permit the extension of the piers and bulkheads eastward and thus provide greater facilities for transfer of freight, which is very desirable, but it must also be remembered that to provide for a rapid delivery and removal of freight there must be a coincident arrival of ship and cars or else a sufficient storage capacity to provide for the delay or shortage of either. To reach the Delaware front, the freights must be hauled across the city *via* Willow Street or Washington Avenue, or else by a long detour *via* Greenwich Point or Port Richmond. Each ship carrying 3,000 tons of cargo would require 100 thirty-ton car-loads of freight, and at three cars per 100 feet the length of each train for loading and unloading would be 3,300 feet, or a total of about three-fifths of a mile. But the cars do not run full, and hence the train would, in fact, be longer. At present provision is made for the grain business at Richmond and Girard Point, where there is elevator capacity amounting to about 3,000,000 bushels or about thirty vessel loads, but a visitor to Girard Point would be apt to conclude from the absence of vessels and the general appearance of the vicinity that the company had gone out of business.

What is required to stimulate commerce and to restore to Philadelphia a portion of her old-time activity, is an element which will enable her merchants, manufacturers, shippers, producers and consumers alike to obtain their supplies or ship their products over lines which are virtually independent of combinations, and there is nothing that approaches so near to fulfilling this condition as the waterway. There is the river it is true, but it opens upon the sea, its inland territory is limited to the few miles to Trenton, and even that is restricted by the Five-Mile Bar, which is being improved at Fisher's Point. But if the barrier which has checked the trade with the interior *via* the Erie and Delaware and

Raritan Canals were removed, and the northern waterway opened across New Jersey *via* an enlarged ship canal between Bordentown and New Brunswick, it would do more, I believe, to develop all classes of business and trade in this, as well as other cities, than any project that could be undertaken. The Pennsylvania Railroad Company has leased the Delaware and Raritan Canal for a period of 999 years, guaranteeing ten per cent. interest on a capitalized value of $5,847,400. In 1890, the freights moved over it amounted to 1,209,668 tons. The gross receipts were $509,162.76, and the expenses $415,326.08, giving net receipts on the business transacted $93,836.68, but with the interest and taxes the total losses for the year amounted to $565,435.56, or over $500,000.

Contrasting this with the business done in 1866, its most prosperous year prior to the lease, we find expenses, $360,513.83; receipts, $1,294,156.69; profits, $933,642.86, which was nearly twenty-three per cent. of the capital invested in the canal ($4,381,251.28), while for the same year the Camden and Amboy Railroad barely earned five per cent. on its capital of $10,099,000.97. At present a large amount of the coal to eastern ports goes out by the Capes in colliers, which if the canal were enlarged, could save considerable time by traversing it. The grain and ores of the lake region could also be delivered in this city at less cost than at present and the stimulus given to trade and population would rapidly compensate the railroads for any temporary loss they might suffer from a diversion of a portion of the traffic. Such is believed to be the lesson of experience elsewhere.

If the cost of this line were to amount to $20,000,000, a traffic of only 2,000,000 of tons at fifty cents per ton, which is believed to be considerably less than the present rate by water, would pay five per cent. on the cost, and this traffic is less than the average for a number of years prior to the lease of June, 1871. Can Philadelphia afford to wait 979 years for a consummation so devoutly to be wished? But this is a project of national importance and has been frequently urged from the foundation of the Republic. It was one

of the features of the great log rolling bill introduced into Congress in 1812, in behalf of national aid for the Erie Canal, and has been frequently revived and urged by various interests, but as yet without success. Under existing methods of administration it will require the united influence of the Atlantic Coast States as well as of those along the Great Belt waterway, all of which will be benefited, to induce the Government to inaugurate the undertaking. It is certainly worthy the effort.

I have placed this enterprise first in importance because I believe it will produce the greatest amount of good, both locally and generally, but I would not ignore those works of lesser importance which are distinctly within the jurisdiction of the municipality or of the individual. Unfortunately there has been too little concerted action on the part of our citizens in the way of public improvements, and it is only when aroused by some threatened or actual calamity that sufficient interest can be awakened to prevent it.

After a long contest the Baltimore and Ohio Railroad was admitted and the Reading Terminal and the Belt Line ordinances were passed. The work on them is now well begun. They will no doubt be of great use to the city and its commerce in facilitating traffic and aiding in the general distribution of freight, but their effects are, to a large extent, local. They will enable the few competing land carriers to reach their principal patrons, but they do not very materially increase the territory tributary to the city or reduce the rates of transportation, as would be the case with the proposed waterway if under national control or even under a corporate body charging a limited tariff.

Although much time has been given to the commercial aspects of this question rather than to the physical, it seems to be necessary, to awaken if possible, a greater public interest in its importance and to concentrate attention upon its political relations, for it should certainly be fostered by the Government, but this will only happen when the wish of the people is made manifest by instructions to their representatives.

PHYSICAL CONDITION OF THE PORT.

Although the water frontage of this city is about twenty-five miles in length only a small portion of it has been developed, a large portion being Government property and other portions being cut off by the Five Mile and Horseshoe Bars. Immediately in front of the city the stream is occupied by Smith's and Windmill Islands, which have recently been purchased, at a cost of $708,652.86. The contract for their removal was let last spring and is progressing slowly. As the question is often asked whether this improvement will be permanent it may be stated that the mere removal of the islands without a simultaneous contraction of the river banks so as to maintain a constant cross-section, will result in hastening the deposits by reducing the velocity of the stream. As this formation is one produced by the river and is situated on the middle ground between the paths of the flood and ebb currents, it is the natural dumping ground of the stream and unless there be some auxiliary work to bring those two currents more nearly into coincidence, the bar must ever remain.

But there is no provision in law requiring the riparian owners to extend their piers to the new Port Warden's line which has been recently established by the Secretary of War and which lies in the deep water of the main channel. Unless this work is done at a number of points at the same time with the removal of the islands, the amount of material to be dredged will be found to be largely in excess of that now in place and the desired result will be very much delayed, as well as the expense increased.

Recent specifications provide that "the rate of progress of the excavation is to be determined by the rate of advance of actual wharf constructions to the new harbor lines so as to maintain the assigned section of the new channel." But as there is no law requiring property owners to extend their wharves into water from forty to nearly sixty feet deep, and as none have done so, it would seem that the work of excavation should be suspended, as it has been for some time past, though it is believed from a different cause.*

* This should not be misunderstood to mean an official suspension by the Government, which at this date has not been ordered. L. M. H.

Moreover the jurisdiction over the harbor lines appears now to be vested by Act of Congress, in the Secretary of War; by Act of Assembly, in the Board of Port Wardens, subject to ordinance of City Councils, and the Board's authority in this matter is restricted to granting permits and is not mandatory as to constructions or extensions of piers.

Again, there is another body, the Board of Harbor Commissioners, appointed by the Presidents of Select and Common Councils, under an ordinance of the city passed July 8, 1879, whose duty it is to "devise, consider and present a plan or plans for the preservation and permanent improvement of the harbor and the port of Philadelphia, and for the increase of its landing accommodations."* For a time this Board was assisted by an Advisory Board composed of an officer of the Engineer Corps U. S. A., an officer of the Navy, and an assistant from the Coast Survey, but this Advisory Board was recently disbanded. There is also a Board of three U. S. Engineers on the Permanent Improvement of the River, and a U. S. Engineer detailed by the Secretary of War as Consulting Engineer to the Harbor Commissioners in lieu of the Advisory Board.

Thus there would appear to be ample provision for the making of plans, but virtually none for their execution, excepting so far as the navigable channel is concerned or as it may be found to be to the interest of the private owner to improve his property subject to restrictions as to length. It must be evident, therefore, that before a well-digested plan for the improvement of our Delaware River front can be executed, there should be authority vested in some central body to condemn and purchase property, and to build and lease such wharves and docks as may be necessary to conduct the business of trans-shipping freight.

As the vested interests along the river front are numerous and the properties very valuable it will be many years before such a symmetrical development may be expected, and there are other reasons why the consummation of a reorganized commerce at this point may be long deferred.

* The writer is indebted to Wm. R. Tucker, Secretary of the Philadelphia Board of Trade, for this information.

On the other ha d we are not devoid of resources, for there is as yet a comparatively undeveloped frontage, of great value, available near Greenwich Point on the Delaware, and on both banks of the Schuylkill, which flows through the heart of the city, where there are ample opportunities for developing commercial facilities far greater than those now existing and at a comparatively small cost. The principal railroads either have tracks laid to or are within a short distance of the mouth of the Schuylkill, and freight is daily carried past that point to the Delaware front only to be returned to the same point by water on its way to the Capes, thus doubling the haul and obstructing the city streets by the surface traffic. The Belt Line will bring this section within a few minutes' ride of the Custom House and even without it the Chester branch of the Philadelphia and Reading Railroad renders it possible to reach the business portion of the city in a very short time.

This would appear to be the section of the city best adapted to meet the commercial requirement of its immediate future, and I believe it will not be many years before very material improvements will be found there. It is not generally known that about one-third of the foreign commerce of this port goes out of the Schuylkill. It is not very long since one of the Allen Line steamers was nine days in getting through an ice pack on the Horseshoe shoals near League Island. Already the railroad companies are seeking terminals at Marcus Hook and Chester, beyond the city limits, and it certainly looks as if they intend to utilize these points at the expense of the city.

There is not time to review the physical condition of the Delaware River from its mouth to the port, but it is worthy of note that it is not all that could be desired, although, thanks to the prompt action of the Engineer in Charge, Major Raymond, its condition has been considerably ameliorated at one of its most dangerous points. Between February 22, 1890, and May 8, 1891, or in less than fifteen months, at least forty-eight vessels struck on or near the Bulkhead Shoals, and so serious had this obstruction become that in March last no less than seven steamers ran aground, two of which were detained nearly twelve hours.

A jetty is now being built there which it is expected will aid in keeping open the channel which has been deepened by dredging.*

There are several other points where the depth is barely sufficient, as at Dan Baker Shoal, Maiden Island Bar, Cherry Island Flats, etc., but taking it as a whole the river is regarded as one of the best waterways on the Atlantic, whether by day or night.

The Delaware Breakwater can no longer be regarded as a harbor, and the closing of the "gap" between the ice breaker and the breakwater, which is still in progress, will not materially enlarge its capacity or depth. The harbor has shoaled, from over twenty-five feet to less than seventeen. In some places near the breakwater only eleven feet are to be found. This is the inevitable result of all structures so located as to intercept the currents. Had the ice breaker been removed, as proposed ten years ago, and its material been deposited along the site of the gap, the result would have been a great improvement.

The term, harbor of refuge, is now a misnomer, for in the storm of March 12, 1888, no less than twenty-seven vessels which had sought shelter behind the breakwater were dashed to pieces and many lives were lost—and again in September of the year following, twenty-three vessels shared a similar fate, making fifty vessels lost in eighteen months.

The effect of the present structure will be to create an artificial island with a submerged embankment connecting it with the shore.

We have seen what the facilities are for bringing freight to our port by land and have discussed all too briefly the opportunities for handling such freight in transit. Let us now note the provision made for its transportation by water. This will be shown by giving the list of vessels engaged in the carrying trade to foreign or domestic ports from this city, as follows:

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* At the time of going to press it is unofficially stated that the single jetty at this point has given all the depth required for the largest vessels.

L. M. H.

There are eight foreign steamship lines at present running to this port, viz:

Line.	*To and from.*	*Number of Vessels.*	*Total net Tonnage.*
Allan Line,	Glasgow,	3	5,610
American Line,	Liverpool,	6	13,960
Atlantic Transport Line,	London,	7	13,853
Baltimore Fruit Company,	West India,	3	1,593
Howes Fruit Line,	West India,	3	1,241
North Atlantic Trident Line,	London,	7	12,465
Red Star Line,	Antwerp,	2	4,486
Spreckels Line,	Hamburg,	4	5,490
		35	58,698 tons

Coastwise steamship lines number nine, as follows:

	Steamers.	*Net Tonnage.*
Boston and Philadelphia Steamship Line,	4	4,264
Clyde Line, Richmond, Norfolk, etc.,	5	3,588
Clyde Line, Philadelphia, Albany and Troy,	1	372
Clyde Line, Philadelphia and New York,	5	1,397
Ericsson Line (Baltimore),	5	1,483
Ocean Steamship Company, of Savannah,	1	892
Philadelphia, Fall River and Providence Line,	3	2,335
Philadelphia and New York (Mercer & Co.),	1	197
Phila. and Reading Coal and Iron S. S. Line,	12	8,619
	37	22,897 tons

There is only one sailing vessel line running from this port; that is, Sutton's Despatch Line to San Francisco. During the past year eight ships have been chartered for this line comprising a net tonnage of 12,618.

These make a total of eight foreign lines of thirty-five vessels, carrying 58,698 net tons, and ten coastwise lines of forty-five vessels, carrying 35,515 tons.

By the way of comparing this with our sister city of New York, it is stated that in 1890 she had of—

	Vessels.	*Tons.*
Sailing vessels,	1,976	409,468
Steam vessels,	1,032	374,673
Total,	3,008	784,141

in addition to which there were 230 canal boats of 23,709 tons and 671 barges of 140,540 tons.*

* John H. Gould, in *Scribner's Magazine*, November, 1891, "The Ocean Steamship as a Freight Carrier."

The canal boat business of Philadelphia is fast becoming extinct, although it was the cheapest method of bringing coal to this city, while the canal was maintained in good order.

Before the lease to the Philadelphia and Reading Railroad, July 1, 1870, the rate by canal was only one-half the subsequent rate by rail, and the canal paid.

Under the terms of this lease the railroad company agreed to guarantee the interest on the stock and bonds of the Schuylkill Navigation Company, amounting to $655,000 per annum, but in consequence of the policy of the railroad, and for other reasons, it went into the hands of receivers, and these guarantees were unfulfilled. The Navigation Company was subsequently asked to take back its property, but without any assurance that the railroad would furnish it with coal for transportation. Under these circumstances the request was of course declined. It was testified by the late President of the railroad company before the Master that all of the net revenues of the company up to that time had been earned by the canal. And yet this, the most profitable part of the company's property is allowed to fall into decay, while the more expensive method of transportation, viz: that by rail, is fostered at the expense of every coal consumer in this as well as other cities. The only party who can utilize this waterway for its legitimate purpose is the Reading Railroad Company, and such use of it would undoubtedly greatly increase the revenue of that company, as well as benefit the city at large.

The citizens of the port of Philadelphia have a direct pecuniary interest in the inquiry, Why does the Philadelphia and Reading Railroad Company desire to sell this dilapidated canal to the city as a conduit for the supply of water, rather than utilize it for the transportation of coal to this and other ports?

As the largest manufacturing centre on the continent, Philadelphia needs above all things cheap fuel, and debarred as she is from the use of natural gas, she is losing a number of industries which have been attracted to the gas belt. Her rate of growth during the last decade has been exceeded

by almost every town or city of any size in the State. Thus while Pittsburgh has increased at the average rate of 5·26 per cent.; Pottstown, 15; Reading, 3·6; Scranton, 6·4; Shamokin, 7·6; Braddock, 15·8; Steelton, 27·8; Philadelphia's average yearly rate of increase is only 2·3 per cent.

This city has been considered fortunate in her location due to the proximity of this prime necessity—coal—but her vantage ground is destroyed by the improved lines of transportation to other cities and the development of new fields. Thus Chicago is abundantly supplied from the extensive deposits of Indiana and Illinois, and consumes more coal per capita than her Eastern rivals. In 1889, 4,665,258 tons were consumed in Chicago, of which more than two-thirds was bituminous, an average of 4·5 tons per individual.

New York	burned	5,153,436 tons,	or	3·4 per capita.
Philadelphia	"	4,107,281 "		4·1 "
Brooklyn	"	2,000,000 "		2·5 "
Boston,	"	1,766,410 "		3·9 "
Baltimore,	"	1,108,613 "		2·5 "
Scranton, Pa.,	" only	132,145 "		1·8 "
Reading, Pa.,	"	391,846 "		6·7 "
Newark, N. J.,	"	544,076 "		3·0 "

The amount of coal delivered to vessels for their own fuel at the four ports was as follows:

For New York,	1,322,895 tons,	65 per cent. approx.
Philadelphia,	297,609 "	14 ±
Baltimore,	227,000 "	10 ±
Boston,	70,267 "	3 ±
Other Atlantic and Gulf,	80,000 "	3·8±
Pacific,	93,000 "	4·2±
	2,090,771	

These statistics barely need comment, they tell their own story, and show the importance to this city of creating and maintaining an unlimited supply of cheaper fuel for home consumption, manufactures and commerce, and this can best be done by a revival of interest in the Schuylkill Navigation Company's waterway, and an earnest popular

appeal to the railroad companies which have throttled these cheap lines of communication on the flanks of this port, either to utilize these channels themselves or permit others to do so, for the public good. It appears to be the policy of the railroads to persist in transporting by rail when there are many articles of the grosser kind which could be carried much more cheaply and quite as expeditiously by water, thus producing a greater revenue for the transporting company, and at the same time reducing the cost to the consumer.

As patrons of these great companies may we not respectfully inquire why these facilities are not utilized to their fullest extent, for the benefit of all the parties at interest, and in the absence of a satisfactory explanation, urge upon the aforesaid companies the propriety of inaugurating a different policy whereby the waterways may be rehabilitated and employed to their full capacity. Then will the Port of Philadelphia be restored in large part to its old-time prestige.

The lecture was closed by projecting upon the screen a number of views of foreign and other harbors crowded with shipping, as at Marseilles, Trieste, Havre, Bordeaux, Liverpool, San Francisco, Boston and New York, and the plans of the Manchester and of the proposed ship canal from the Delaware River to New York Bay were exhibited. This latter project was so located as to avoid many of the difficulties incidental to an enlargement of the old Delaware and Raritan Canal and to shorten the distance from forty-four to thirty-three and three-fourths miles. There would be two lifts of twenty-five feet each and two tidal locks. The summit level would be fifty feet above mean low water, and the section of the canal is designed to be twenty feet deep by ninety feet bottom width, 150 feet surface width and ten feet bermes, giving about 26,000,000 cubic yards of excavation.

It is estimated that the entire work from Philadelphia to Staten Island would cost $12,500,000.

This would constitute the most important link in the interior waterway of the Atlantic Coast, connecting the

most populous and most valuable centres commercially and strategically. Its advantages to the entire country can hardly be overestimated as a factor in preserving peace and promoting prosperity.

EXPERIMENTS MADE TO ASCERTAIN THE SPECIFIC VOLUMES OF THE SATURATED VAPORS OF WATER, BISULPHIDE OF CARBON, AND ETHER, TOGETHER WITH VARIOUS MEASURES CONCERNING THE LATTER; ALSO THE DETERMINATION FROM THE EXPERIMENTAL DATA THUS OBTAINED OF THE MECHANICAL EQUIVALENT OF HEAT.

By A. Perot.

Translated by Chief Engineer Isherwood, U. S. Navy.

[*A thesis presented to the Faculty of Sciences of Paris.*]

The specific volume of saturated vapors, or what inversely amounts to the same, namely, the mass of their cubic centimetre, is of the greatest theoretical interest, because it is a factor in numerous thermodynamical equations from which the mechanical equivalent of heat may be calculated.

The experimental researches for determining this quantity are very few, and they are in principle similar to Gay-Lussac's method for measuring the densities of dry vapors. I shall pass them in rapid review.

The first experiments were those made in 1860, by Messrs. Fairbairn and Tate,* on the vapor of water. Their process consisted in introducing a known weight of water into a vacuous vessel of known capacity, and ascertaining the temperature at which the whole of the water was transformed into saturated vapor. The water, contained in a completely filled and sealed phial, was introduced into a balloon that communicated by means of a manometrical tube with

* *Philosophical Trans.*, 1860, and *Phil. Magazine*, vol. xxi, 4th Series, p. 231. 1861.

a surrounding inclosed space in which the saturated vapor was produced in presence of an excess of water. This inclosed space surrounded the balloon in such a manner that the temperature in the space and in the balloon was exactly the same. The rise of the temperature broke the phial, but as long as the whole of the water in the inner balloon was not vaporized, there was no difference between the heights of the two columns of mercury of the manometer; as soon, however, as the vaporization was complete —the temperature continuing to increase—the mercury began to rise in the manometrical branch communicating with the balloon, and at that instant the temperature of the thermometer, and the volume occupied by the vapor, were noted, which latter is possible when the manometrical tube has been gauged. The levels were observed with a magnifying glass, and the thermometer—directly immersed in the vapor—was corrected for the influence of the pressure upon it. Knowing, then, the volume occupied by the vapor, the weight of water vaporized, and the temperature, the specific weight of the saturated vapor can be easily calculated. The experiments show that this weight is always greater than that which is due to the laws of Mariotte and Gay-Lussac.

This elegant and simple method of Messrs. Fairbairn and Tate also allows the dilatation of superheated steam to be determined, for the pressure of the vapor is known from the difference between the levels of the mercury in the two legs of the manometrical tube, while its volume can be ascertained by previously graduating that tube in divisions of equal capacity,

The arrangement of the apparatus is adapted for measuring specific volumes, because the errors which may be made in determining them are of the same order as those which may be made in ascertaining the temperature. For example, if it be supposed that the manometrical tube had one square centimetre of section, and that $2x$ denotes the difference between the level of the mercury in the two legs of the manometer produced by $0^{c}.1$ increase of temperature above the temperature of exact saturation, x could be

calculated according to the following equation given by the experimenters.

$$H'V' = HV\left(1 + \frac{0.1}{r}\right)$$

the pressure H and the volume V being relative to the exactly saturated vapor, and H' and V' to the condition produced by the 0°·1 elevation of temperature; knowing also that

$$H' = H_{t+0.1} - 2x$$

that $V' = V - x$, and substituting for r the value given by Messrs. Fairbairn and Tate. When $t = 70°{\cdot}75$ for example, $r = 83{\cdot}33$, $H_{70.75} = 24{\cdot}1$ centimetres, $H_{70.85} = 24{\cdot}2$ centimetres, there would be approximately

$$x = 0{\cdot}036 \text{ centimetre},$$

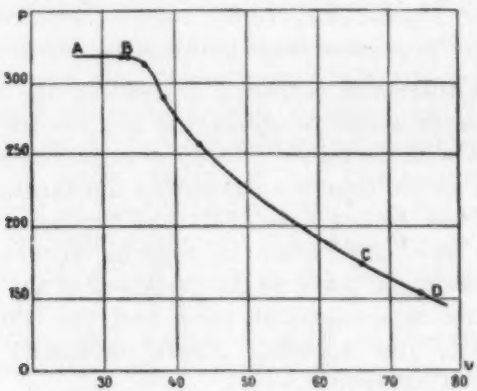
so that the difference of level $2x$ between the two legs of the manometer would be about 0·07 centimetre, a quantity appreciable with certainty; the error to be feared as regards the volume would then not exceed the diminution of volume resulting from an increase of 0°·1 of temperature. There are, it is true, difficulties as regards accurate reading, the light having to traverse the thickness of the glass before reaching the manometrical tube and the thermometers, consequently, the accuracy above indicated should be regarded as a maximum.

In 1868, Herwig* undertook to measure anew the variations of the product PV of the pressure of a given mass of vapor by its volume, when that vapor passes from the condition of saturation to the condition to which the laws of Mariotte and Gay-Lussac are applicable. He varied the pressure of a given mass of vapor at constant temperature, and measured the volumes successively occupied. The results that he obtained relatively to the variation of the product PV, in operating on alcohol, chloroform, and the bisulphide of carbon, are interesting, but his method considered as one for the determination of specific volumes, is open to some objections. In these experiments he failed to

* Herwig, *Pogg. Ann.*, vol. cxxxvii, p. 19. 1869.

measure with precision, at a constant temperature, the volume occupied by the mass of the substance experimented with when the saturation was exact; that is to say, at the moment when in augmenting the volume progressively, the pressure commenced to diminish: this diminution of pressure was the sole criterion by which he could judge when the saturation was exact. In estimating the value of this method, a clear understanding must be had as to whether that indication was sufficiently sensitive, and, if not, whether, for appreciable variations of pressure, variations of volume are negligable; now it can be easily comprehended that such is not the fact.

Fig. 1.



Taking p and v as variables, representatives of the condition of the substance, let there be constructed, point by point, with the numbers given by Herwig, the corresponding isotherm for the vapor of alcohol at, for example, $t = 57°{\cdot}8$:

	cm.	*cm.*	*cm.*	*cm.*	*cm.*	*cm.*	*cm.*
p, ...	31·581	31·580	31·163	28·903	25·713	17·306	15·400
v, ...	33·0	33·3	36·0	38·7	43·7	65·7	74·0

Exact saturation occurs, according to Herwig, when $p = 31{\cdot}580$, and $v = 33{\cdot}3$. The trace (*Fig. 1*) is composed of a *rectilineal* part AB parallel to the axis OV, corresponding to the saturated condition, and of a *hyperbolic* part, corresponding to the condition of a vapor following the laws of Mariotte

and Gay-Lussac, united by a *connecting* curve at B to the rectilineal part in such manner that near B the variations of pressure corresponding to very large variations of volume are very small, in which case the value of V must be extremely uncertain.

Herwig was led by the lack of sensitiveness of his method to invent an empirical law connecting the product PV of a vapor following the laws of Mariotte and Gay-Lussac, with the product pv of saturated vapor; he put

$$PV = pv\, C \sqrt{T},$$

C being a constant and T the absolute temperature, then verifying the equation from such of his experimental groups whose values of p, v and T he considered to have been determined with the most precision, he obtained for it a value of C and corrected the results of his other experiments by means of that formula; in other words, he determined empirically the specific volume. This had the effect of replacing the trace representing the states of exact saturation, by the following one:

$$p\, v = \frac{PV}{C \sqrt{T}} = \frac{1}{C} P_0\, V_0 \sqrt{T} = C_1 \sqrt{T};$$

which can only be applied within very restricted limits of temperature.

In 1880, Messrs. Wüllner and Grotian* repeated these measurements with an apparatus which may be considered as a combination of those of Herwig and of Messrs. Fairbairn and Tate. The space where they produced and investigated the vapor was within an assemblage of three inverted balloons whose necks, graduated in parts of equal length and equal volume, communicated with a receptacle filled with mercury under a known pressure; a fourth balloon, under the same conditions, contained the vapor in a constant state of saturation owing to the presence of an excess of liquid; it served as a bench-mark in the experiments and corresponded to the space which surrounded the

* Wüllner and Grotian, *Wiedemann's Annalen*, vol. xi. p. 545 (1880), and Wüllner, *Lehrbuch der Experimental-Physik*, vol. iii, pp. 705 and 758 (1885).

balloon in the apparatus of Messrs. Fairbairn and Tate. Finally, the four balloons were immersed in a liquid bath, kept properly agitated, whose temperature was exactly measured. The volumes of the first three balloons were in the ratio of 1, 2 and 4. The weight of liquid introduced into them was in the same proportion as the volumes; the liquefaction of the vapor would be effected at the same moment in the three spaces. The temperature was raised, and the pressure was so regulated as to cause dry vapor in the three balloons: the temperature being maintained constant, the vapor was very slowly compressed, and the instant that fog or wet steam appeared on the sides was considered to be the instant of exact saturation. The observations made on the three balloons were always concordant, but the liquefaction was produced by a pressure a little less than the maximum pressure of the saturated vapor observed in the fourth balloon.

In the first place, as Mr. Wüllner remarks, if the apparent irregularity of the condensation then found was due to the action of the sides, its effect ought to vary with the proportion of the surface of the balloon to the volume of the same; the greater that proportion the greater should be the condensation of the vapor on the sides, and *vice versa*. In operating with balloons of unequal capacity, there should be found for the specific weight of the vapor, numbers varying in the same direction as the capacities, or this cause amounts to nothing.

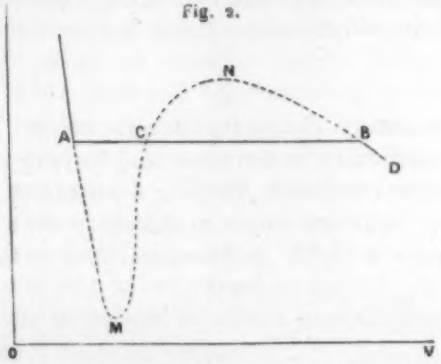
The influence of the sides, if it exist, would be masked by much more important phenomena. It seems that this apparent irregularity—(and a considerable one, too, since the ratio of the observed pressures to the pressures corresponding to the saturated vapor, has, for water, the sensibly constant value of 0·01)—can be explained in the following manner:

In considering the assemblage formed by the isotherms corresponding to temperatures below and above the critical point of a substance, Mr. James Thomson* was led to think

* J. Thomson, *Proceedings of Royal Society of London*, November, 1871.

that the passage from the gaseous state to the liquid state could be insensibly made, the substance remaining homogeneous. The isotherms representing such a change of state have no horizontal part, but are continuous and have a form

Fig. 2.



like *AMND* (*Fig. 2*). Several scientists, taking this conception as a basis, have devised different formulæ to represent the law connecting the pressure with the volume. Among them, Mr. Clausius* has proposed the following:

$$p = \frac{RT}{V + a} + \frac{F(T)}{(V + \beta)^2}$$

R being the constant of the law of Mariotte; T the absolute temperature, a and β two specific constants of the substance.

The numbers calculated by Mr. Sarrau† resulting from the application of this formula to carbonic acid, are in very satisfactory accord with those obtained by Messrs Cailletet and Mathias‡ in their recent experiments on liquefied gases.

If, in this formula, T be supposed constant, the isotherm represented will have, in fact, the form shown in *Fig. 2*. Mr. Clausius has elsewhere made it evident that the horizontal part found in constructing the isotherm with the experimental data, should be so placed that the areas *AMC* and *CNB* would be equal.

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* Clausius, *Wiedemann's Annalen*, vol. ix, p. 127, 1879.

† Sarrau, *Comptes Rendus*, vol. ci, pp. 941, 994 and 1145.

‡ Cailletet and Mathias, *Journal de Physique*, 2d series, vol. v, p. 549, 1886.

What is the nature of the point B considered as appertaining to the trace $EACBD$? Is it a *curved connecting point*, or an *angular point*? If it were an angular point, the volume augmenting in departing from a point in the straight line AB, the variable B would enter abruptly into the expression of the pressure, which seems could not be the case as

$$\frac{dp}{dt}$$

would then become a discontinuous function.

With this difficulty in the case, and having regard to the isotherm constructed with Herwig's numbers, represented in *Fig. 1*, there appears more probability that the straight line AB connects with Mr. J. Thomson's curve in the manner

Fig. 3

shown in *Fig. 3*, and there follows that the representative point of the state of the substance at the instant when there was no more liquid, and when the vapor was still saturated, is not on the parallel to the axis of the volumes, but below at B', so that *the condensation will commence at a pressure less than the maximum pressure of the vapor*. Thus what Messrs. Wüllner and Grotian have measured is the specific volume of the vapor in a particular state, a volume which is not the inverse of the specific weight of saturated vapor in presence of an excess of liquid.

Messrs. Fairbairn and Tate, as well as Herwig, measured the specific volume when there was not enough liquid to produce the maximum tension; in other words, if Messrs. Wüllner and Grotian sought the abscissa of the point B', Fairbairn and Tate, and Herwig, determined that of the point B.

Referring, further, to the measures of the specific volume of the saturated vapor of chlorhydric gas, made by Mr. Ansdell,* and to the determinations effected by Messrs.

* Ansdell, *Proceedings Royal Society*, vol. xxx, p. 117, 1879.

Cailletet and Mathias* on liquefied gases, these measures being made according to the same principle as those of the experiments of Herwig: there was determined the mass of a given volume of gas under known conditions of temperature and pressure. This mass, first reduced to the liquid state, is vaporized and the volume measured at the instant of exact saturation as near as can be detected, either as in the case of Mr. Ansdell, by observing the movement of a manometer, or, as in the case of Messrs. Cailletet and Mathias, by watching the moment when the last drop of the liquid disappeared. These measures are very interesting, not only because they are the first made on the respective substances, but also because they have a degree of precision very difficult to attain when such high pressures are employed; the methods, however, are not sufficiently exact for the object I have in view.

From the preceding exposition there can be drawn the following conclusion: All the measures of the specific volume of saturated vapors, that have been made, or attempted, by seeking to determine the volume at the state of exact saturation, necessarily include a source of error, small, it is true, but inherent in the methods adopted. To obtain the precise determination of the weight of the cubic centimetre of saturated vapors, it is necessary to operate in the presence of an excess of the liquid. This is what I have endeavored to do, and the following experiments, which I am about to relate, were made under that condition.

This memoir is divided into two parts: In the first, I describe in detail the processes I have employed for measuring the specific volume of saturated vapors; in the second, I apply the data thus found to the calculation of the mechanical equivalent of heat; it contains, further, the determination with a known degree of approximation, of the numerical values of a certain number of important factors employed in this calculation,

* Cailletet and Mathias, *Journal de Physique*, *loc. cit.*, 2d series, vol. v, p. 549, 1886.

But before proceeding, I must be allowed here to express to Messrs. Bichat and Blondlot the profound and respectful gratitude to which they are entitled from me. They have freely placed at my disposal the resources of their laboratory, and if I have profited during several years from the wise counsel and high experience of Mr. Bichat, I am happy to say that Mr. Blondlot has likewise guided and supported me in this my first work.

CHAPTER I.

Measure of the Specific Volume of Saturated Vapors.

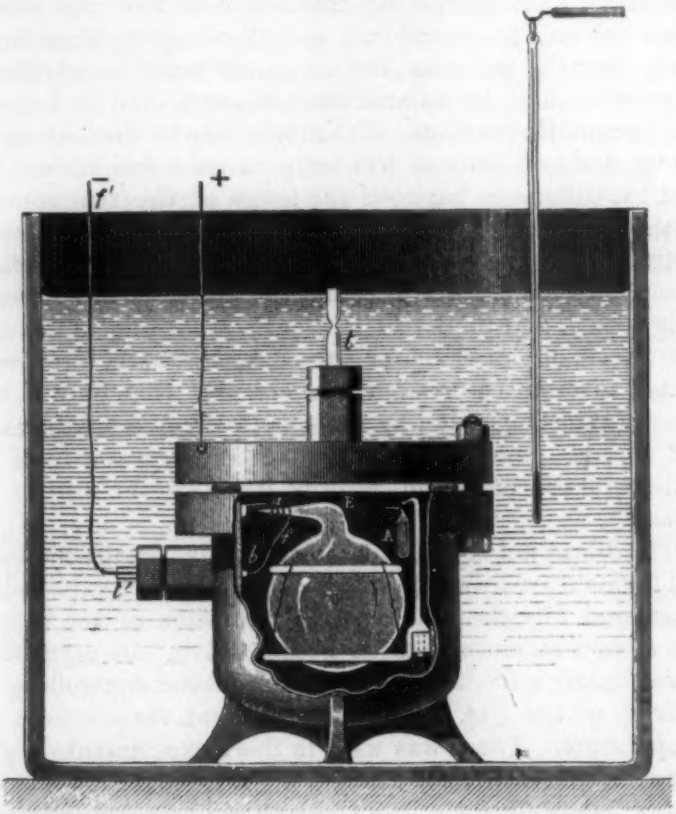
Two methods have been employed for measuring the specific volume of saturated vapors, but in both will be found realized the condition of which I have previously shown the necessity. The weight of the cubic centimetre of vapor, and consequently its inverse, the specific volume, is determined by isolating in an atmosphere of saturated vapor a certain volume, and measuring the mass of that volume.

First Method.—Imagine in a vacuous space E, a balloon, equally void, in communication with it, but which can be isolated at a given instant, and that there can be produced in this space an atmosphere of the saturated vapor of a liquid of known temperature. The balloon will fill with this vapor, and if it be then closed the mass of the substance within it can be ascertained by weighing, and from this mass can be deduced the weight of a cubic centimetre of the vapor, and also its inverse, the specific volume.

This method of experimenting has been realized in the following manner: the inclosed space where the saturated vapor is generated is the interior E of a bronze boiler (*Fig. 4*), which can be closed by a cover bolted on, and in which a vacuum can be formed by means of a glass tube t, passing out through a packed stuffing box. After this boiler has been several times washed out by the liquid which is to be the subject of the experiment, in order to eliminate all trace of any other substance, there is placed on a support in it a balloon, tared, full of dry air, and similar to those employed for determining the density of vapors according

to the process of Dumas; the method employed for drying the balloon is the one used by Regnault: produce a vacuum in the interior and allow the air to enter about thirty times. Around the extreme end of the neck of the balloon, which has been drawn out to a fine point, there is coiled a plati-

Fig. 4.



num wire *f*, one of whose ends is fastened to the side of the boiler at *a*; the other end *b* is secured to another platinum wire *f'* which passes through the side of the boiler in a glass tube *t'*, and is thus isolated from the boiler. At the side of the balloon there is placed in the interior of the boiler a phial *A* full of the liquid to be operated on. To

secure a hermetical joint without the use of any fatty substance, there is placed between the boiler and the cover a circle of lead wire which is flattened by screwing up the bolts. The two stuffing boxes for passing out, the one, the isolated platinum wire; the other, the glass tube *t*, are packed either with rings of cork or with a mixture of flax and talc. The interior of the boiler is dried by several times causing a vacuum in it and allowing dry air to enter, then, after the last time, the air is extracted as completely as possible, first, by a Carré machine, and then by a mercurial pneumatic machine. The rarefaction in the last experiments made on ether at low temperatures, was so complete that the difference between the levels of the two columns of the manometer was not more than about half a millimetre. The glass tube *t*, which established the communication between the machine and the boiler, is now hermetically sealed, and the latter is placed, according to the case, into a bath of olive oil, or into a water bath, previously heated to about the desired temperature. The bath is kept in continuous agitation by a mechanically operated sucking and forcing pump, which draws the oil or water from the bottom of the bath and returns it above the top of the boiler.

The dilatation of the liquid in the phial breaks the latter and furnishes within the apparatus the saturated vapor which enters and fills the balloon. The duration of the heating was always more than three hours, and in one experiment it was nearly a day and a half. A regulator controlling the delivery of the gas, prevented too great variations in the temperature. There was used in these experiments a glycerine regulator, the advantage of which consisted in combining independence of the atmospheric pressure with sufficient sensitiveness; at 150° the variations, very rapid, did not exceed $\frac{1}{4}$°. At the end of an experiment I was particular to maintain for twenty or thirty minutes the temperature constant, at least, to about $\frac{1}{10}$°, with increased care for preventing cooling effects due to exterior causes. For closing the balloon, there was passed through the platinum wire *f* the current from a small Gramme machine, one pole of which

was attached to the side of the boiler and the other to the wire *f'*. The platinum wire *f* became highly heated, melted the glass, and the point was hermetically sealed the same as if done by a blow-pipe.

The boiler is lifted from the bath and allowed to cool, then the cover is removed and the balloon, in which a part of the vapor has been condensed, is taken out. The operation is finished by measuring the density of the dry vapor according to Dumas' process. The gauging is made either with water, or, preferably, with mercury; the air which remains is ascertained, and its volume should never exceed four cubic centimetres, 200 cubic centimetres being the mean capacity of the balloon.

The following are the results I have obtained in operating at different temperatures on water, on the bisulphide of carbon, and on ether:

Name of the Liquid.	*Temperature in Degrees.*	*Volume of the Balloon at 0° in Cubic Centimetres.*	*Specific Volume of the Vapor in Cubic Centimetres.*
Water,	68·20	243·0	5747
	88·60	188·1	2531
	98·10	222·3	1782
	99·60	219.0	1657
	101·50	196·92	1583
	124·10	169·92	766
Bisulphide of carbon,	84·60	171·19	116·3
Ether,	28·40	174·57	426·2
	30·00	177·98	400·0
	31·70	182·42	375·1
	31·90	182·64	373·0
	57·90	208·40	168·0
	85·50	215·50	77·77
	110·50	150·35	43·94

I will here give some information relative to the practical particulars of the experiments.

I have not been able to experiment on water much above 100°, because the surface of the glass becomes greatly altered above this temperature by the saturated vapor; thus, with 140°, at the end of three hours' heating, the interior of the balloon had been so attacked that a white and opaque skin of silica would scale off like a thick pellicle of retractile collodion. The experiment in the above table, made

at 124°·10, should, for this reason, be considered doubtful. At 101°·5 I have not observed any attack of the kind. The experiment made with that temperature lasted thirty-two hours, and the glass, when the balloon was lifted out of the boiler, was as transparent as when the balloon was placed in it. This experiment, made under eminently favorable conditions for such an attack on the glass, shows that below 100° in the other experiments, which lasted at the longest five hours, the attack was absolutely nothing.

When the bisulphide of carbon was experimented with, the sealing of the balloon was attended by some difficulties. This substance is decomposed at a red heat, and the sulphur combining with the platinum forms a fusible sulphuret of platinum, the wire breaks, and the current no longer passing, the balloon frequently remains open.

With ether, the current should be sent rapidly; the point of the neck should be of very thin glass, for a deposit of carbon, due to the decomposition of the ether at a high temperature, is quickly produced on the wire, which deposit hindering the contact of the glass with the metal prevents their being soldered together. If the point be thick, the balloon does not become closed, while, if the glass be thin, it is melted before the carbon deposit can acquire any notable thickness. This partial decomposition of the vapor cannot in the least falsify the results of the experiments, for it takes place outside of the balloon, into which the gas cannot penetrate during the very short time of the passage of the current. In the first experiments made on ether at low temperatures, the dilatation of the liquid was not sufficient to break the phial containing it, in which case I opened the phial by a process the inverse of that by which I had closed the balloon, namely, by means of a current penetrating into the apparatus by a second isolated wire, I melted the point of the phial, and there being a vacuum in the boiler, a hole was produced by the pressure of the vapor through which the latter escaped.

[*To be continued.*]

FOURTH CENTENNIAL OF THE DISCOVERY OF AMERICA.

[*Official Announcement of the Historical American Exhibition of Madrid.*]

One of the acts with which the Spanish Government has decided to commemorate the Fourth Centennial of the Discovery of America, as ordered by the Royal Decree of ninth of February last, is the establishment at Madrid of an exhibition that is to comprise every kind of American objects, giving at the same time an idea of the civilizations of the New World, anterior to and coëval with the epoch of the discovery and European conquests.

This purpose being known, it seems unnecessary to overrate the importance of this Exposition. The mere announcement of it suffices to enable one to appreciate the great elements that science will find for its progress and the numerous data that arts will collect to complete the knowledge of those mighty races about which so much remains to be known and investigated.

Besides this interesting aspect, the Exhibition symbolizes the homage paid by the present generation to the gallant and fearless navigator, who, with unshaken faith, opened to the Old World's civilization, the vast horizons of an unknown continent, the influence of which, in the course of time, has increased the wealth and prosperity of every country of the earth.

With such patriotic incitements, the committee has not the slightest doubt of your valuable assistance by sending to the Historical-American Exhibition any objects in your possession of American origin or referring to the conquest, anterior to the middle of the eighteenth century, of the following classification:

PREHISTORIC AMERICA.

Plans, models, reproductions or drawings of ancient American caverns and everything showing any trace of their having been used as human dwellings.

Plans, models. representations or drawings, etc., of American menhirs, dolmens, tumuli and other megalithic monuments, with specification, if possible, of the local names by which they are known in the country.

Models, drawings, representations, etc., of the remains of lacustrine dwellings and objects coming from that period. Every kind of objects found inside and near the prehistoric monuments, or graphic designs of the same.

Stone arms and instruments from the paleolithic and neolithic periods; articles made of horn and animal bones. Pottery, ornaments, utensils made of bones, ivory, wood, stone and of any other materials; stone-hammers and mortars. Fossils, or animal bones serving to prove the archæological discoveries of those ancient periods.

Arms, instruments, utensils, ornaments and other implements of the copper and bronze ages.

HISTORIC PERIOD.

Models or representations of ancient American buildings, remains of chapiters, cornices, etc. Polychromatic architecture. Plans, models or drawings of restored monuments.

Statues, fragments of them, busts, bas-reliefs, etc. Pictorial art—painted architectural fragments and paintings on every sort of materials. Engravings and etchings, antique wood carvings.

INDIAN INDUSTRIAL ARTS, ETC.

Clothing and adornment of aboriginal uncivilized and but partly civilized Indians. Implements of war, offensive and defensive, of wood, copper, bronze and iron.

Gold, silver, bone and ivory jewels; necklaces, ear-rings, bracelets, etc. Pottery, household utensils and furniture. Tissues and textiles from which they are made. Apparatus for manufacturing purposes. Articles used in transportation by water and land.

Documents written in their native tongue. Pictures, photographs of Indians and effigies of the same with their

wearing apparel, weapons, etc. Models of Indian dwellings. Indian crania.

CARTOGRAPHY, NAUTICAL INSTRUMENTS, ETC.

Maps, plans, charts, drawings and all that relates to the ancient cartography. Models of vessels anterior to the voyage of Columbus. Carabelas, portions of the same, or of their rigging. Models or drawings thereof.

Astrolabes and nautical instruments, marine charts and maps used at the period of the discovery of America. Objects of personal use of Columbus; pictures of the same. American architectural monuments.

FINE ARTS, ETC.

Ancient architectural monuments, sculpture, paintings, engravings, industrial and artistic works following the discovery, American coins, literary and scientific publications, manuscripts, charts and plans from the discovery to the middle of the eighteenth century.

As you will naturally wish to know the conditions and circumstances attending the celebration of the said concourse, those more important for exhibitors are inserted here below, as consigned in the general regulations approved by the Managing Committee of the Exhibition, viz:

(1) The Exhibition will take place in Madrid, in the palace destined to the Library and National Museum, which will be inaugurated on this occasion, as well as in the Park of Madrid. (Art. 2, of the Regulations.)

(2) The concourse will be opened to the public on September 12, 1892, closing on December 31st, following. (Art. 2.)

(3) The objects destined to the concourse will be delivered to the Spanish Committee of this capital, whose address is given below. This committee will forward, gratis to all applicants, the regulations, instructions and particulars, as also schedules of inscription to be filed by those wishing to be considered exhibitors, and will, in due time, hand over receipts for all objects delivered by the latter.

These objects must be presented in good condition, in cases, and packed with the care required for conveyance.

At the request of applicants and in their presence, the packages delivered by them may be marked and sealed.

Schedules and labels will be furnished to exhibitors wishing to consign their remittances to Madrid. (Arts. 18, 22 and 24.)

(4) Once the packages in the hands of the committee, all expenses of conveyance of same to Madrid and back will be paid by the Managing Committee, the exhibitors thereby incurring no further expense. (Art. 26.)

(5) In the same way in the building and grounds of the Park, the plans of which can be seen at the offices of this committee, the necessary space will be allotted gratuitously to exhibitors to install in an ample and proper manner the objects they present. The cost of the general installation will be at the expense of the Managing Committee. The exhibitor desirous of an accommodation special or distinct from the general one, may have it at his expense, provided the design he must submit to the general delegation be previously approved of. (Art. 30.)

(6) Packing materials and empty cases will be kept in a fit and safe place by the delegation, no charge being made to exhibitors for this service. (Art. 29.)

(7) Exhibited objects may not be withdrawn before the official closing of the concourse, except in case of special permission from the general delegate.

(8) All the installations of the Exhibition must be finished on the 31st of August, 1892. (Art. 32.)

(9) Exhibitors desiring to sell their exhibited objects will mark the price of same on the schedules and labels for the information of the public, as well as for the easier judgment of the members of the jury. (Art. 34.)

(10) Immediately after the closing of the Exhibition, the packing and return of objects exhibited will take place.

The cases or parcels that may not have been delivered in Madrid, will be sent by the general delegation to the committee through which they were received. In their turn the said committee will hand them over to the exhibitors, tak-

ing back, at the same time, the receipts formerly given to the interested parties.

In case of loss of said receipts, they may be substituted by documents proving the property of the objects. (Art. 38.)

(11) To each exhibitor, or in his absence to the representatives, will be given a free pass to the Exhibition. (Art. 44.)

(12) In view of the lists that the exhibitors will hand to the general delegation, this latter will issue likewise, gratis, the necessary tickets for service of care-takers, attendants and workmen required for the installation. (Art. 47.)

(13) All objects from foreign countries to be transmitted to the Exhibition will be considered as a deposit and consequently free from any custom house or toll duties, on condition that at the closing of the Exhibition said objects be returned abroad.

Orders will be transmitted for the land and maritime custom houses to mark and forward all consignments immediately to Madrid. (Art. 52.)

(14) The return abroad of objects exhibited will take place during the term of two months, counting from the day on which the closing of the Exhibition has been declared. (Art. 55.)

(15) The delegation will publish a general catalogue of all the objects that appear in the Exposition, giving the name and address of each exhibitor; and the class, nature and a brief description of everything exhibited. (Art. 56.)

(16) Besides the general service for custody and safety to be organized by the general delegation, the commissaries or delegates of foreign nations, as well as any exhibitor wishing to form an association, may at their own expense appoint special guardians for the security of their respective departments who shall submit to the rules of organization and service determined by the general delegation, and shall wear by previous authorization, the uniform and distinctive marks agreed upon. (Art. 78.)

(17) For the examination and qualification of the merit of the objects exhibited, an international jury will be appointed, and the number of its proprietary substitute

members will be determined in proportion to the number of exhibitors and the importance of the objects exhibited. (Art. 60.)

(18) The prizes to be granted will consist of diplomas of the following categories:

First Prize of Honor,
Gold Medal,
Silver Medal,
Brass Medal,
Honorable Mention.

The diplomas will be accompanied by a medal commemorative of the Exposition, the same for every kind of prize. (Art. 66.)

(19) It will be understood that all exhibitors from the mere fact of appearing at the Exhibition, accept the conditions contained in the General Regulations and any others that may be in future dictated in the matter. Having made known the substance of the contents of the General Regulations of the Historical-American Exhibition, a copy of which will be forwarded to you, should you wish to be an exhibitor, the commission reiterates the request that you will honor the said Exhibition with your presence, and it will have the greatest pleasure in giving you all the information and particulars you may consider necessary to induce you to accept the present invitation which the Managing Committee of Madrid now extends to you through me.

I avail myself of this opportunity to offer you my respects, and beg to remain,

Your obedient servant,
THE VICE-PRESIDENT OF THE COMMISSION,
A. G. DEL CAMPILLO,
Secretary of the Spanish Legation.

WASHINGTON, D. C., December 1, 1891.

EDITORIAL.

We commend not only to our readers but to our legislators, whether readers or not, the able paper of Prof. Haupt in this number. The two subjects which seem to remain a mystery in spite of all efforts to elucidate them are: (1) the decline of the merchant marine of the United States, and (2) the decline of Philadelphia as a shipping and commercial centre. Prof. Haupt's article throws much light on the latter of these questions.

* * *

Attention is called to the circular of the commission for procuring a suitable representation of American exhibits at the Spanish Exposition next year in commemoration of the fourth centennial of the discovery of this continent by Europeans. The display in Madrid will not only not prejudice the success of the larger display in this country, but in fact the more perfect it is, the greater will be the gain to our own fair of the Columbian quadri-centennial in Chicago. As United States citizens also we will accept with pleasure this opportunity of showing good-will and courtesy to the mother of most American nations, the grand old Kingdom of Spain. We have had more than enough lately of strained relations and hard feelings toward other Latin members of the world's family, and it is a relief to be able to prove that our desire is to maintain cordial feelings of mutual respect and esteem with all.

* * *

The management of the weekly illustrated review, *L'Elettricita*, which has appeared for ten years in Milan, has established an international competition for the new form of electric battery which shall be most practical, simple and adaptable to industrial uses. The competition will remain open from January 1st to August 31, 1892. A prize of 2,000 francs will be awarded to the inventor who wins in the competition. The jury will be composed of well-known and competent persons.

The competitors must observe certain regulations of which they may be apprised by addressing the said *Revue*. Address, *L'Elettricita*, via Meravigli 2, Milan, Italy. F.

PROCEEDINGS
OF THE
CHEMICAL SECTION
OF THE
FRANKLIN INSTITUTE.

[*Stated meeting held Tuesday, December 15, 1891.*]

HALL OF THE FRANKLIN INSTITUTE,
PHILADELPHIA, December 15, 1891.

Dr. W. H. WAHL, President, in the chair.

Present, ten members and one visitor.

Dr. Jayne moved that the by-laws be suspended and the regular order of business be done away with. Carried.

The resignations of Messrs. Stevens and Gudeman were accepted by the Section.

A motion renewing the subscriptions to the various periodicals, and authorizing the treasurer to pay for the same, was carried.

The paper of the evening was by Prof. Jos. W. Richards, on "The Specific Heat of Aluminum."

After a *résumé* of the work already done in that direction, Prof. Richards brought forward the results recently obtained by him. The paper was referred for publication.

The meeting then adjourned.

LEE K. FRANKEL, *Secretary pro tem.*

PROCEEDINGS
OF THE
ELECTRICAL SECTION
OF THE
FRANKLIN INSTITUTE.

[*Stated meeting, held Tuesday, December 1, 1891.*]

HALL OF THE FRANKLIN INSTITUTE,
PHILADELPHIA, December 1, 1891.

Prof. EDWIN J. HOUSTON, President, in the chair.

Present, thirty members and visitors.

The minutes of the previous meeting were read and approved.

Three nominations to membership were referred to the Committee on Admissions. The committee reported four elections since last meeting.

The Secretary presented his annual report, which showed an increase in the membership from sixteen at the organization January 17, 1891, to sixty-four at present, with an average attendance of twenty-six at the ten meetings held during the year.

The Treasurer presented his annual report, and it was referred to the Committee of Auditors.

The following were elected officers for 1892:

President—Prof. Edwin J. Houston.

Presidents—Messrs. C. W. Pike and Carl Hering.

Secretary and Treasurer—Prof. L. F. Rondinella.

Conservator—Dr. Wm. H. Wahl.

Mr. H. W. Bartol presented a communication on the "Electric Railway of Buda-Pesth," illustrated. Referred for publication.

Mr. Carl Hering described some details of the "Lauffen-Frankfort Alternating Current Transmission," with illustrations.

Mr. Wm. S. Aldrich read a paper on "Electro-Magnetic Machinery," which was profusely illustrated, and is to be continued.

The Treasurer presented bills for printing, etc., which were approved and ordered paid.

Adjourned.

L. F. RONDINELLA, *Secretary.*

JOVE'S AUTOGRAPH.

BY W. N. JENNINGS.

[*Read at the stated meeting held November 3, 1891.*]

To watch the play of electric fire and listen to the deep echo of its voice has always been to me a most fascinating pastime. Many years ago I noted a great difference between the actual appearance of lightning itself and that depicted by artists such as Doré: in the sky, a graceful, waving ribbon of light, and on canvas, an awkward, angular, zig-zag line. Thinking, perhaps, my eye-sight was defective, it occurred to me to see if the modern extremely sensitive photographic plate could catch and record the true form of an electric discharge, and thus definitely decide the question as to the zigzag or wavy line. The work was commenced, but not until September, 1882, was I enabled to induce Jove to write his autograph; a little *wavy line* about a half an inch long; thus encouraged the task was taken up with renewed interest, which has never flagged since that time, and now it gives me great pleasure to bring before the Electrical

Section of the Institute, a number of photographs representing various types of lightning, the result of nine years' work: (See *Frontispiece.*)

(1) A sketch of the conventional form of lightning as given by artists, and may be termed a "Doré discharge."
(2) Artificial lightning, or Holtz machine spark, the increased thickness being due to the addition of condensers.
(3) Sinuous vertical discharge, with branches, taken August 1, 1885.
(4) "Tree" form of lightning, caught June 1, 1887.
(5) Vertical discharge showing stratified lines near its lower extremity, taken May 29, 1888.
(6) Divided discharge, caught August, 1886.
(7) Double horizontal discharge (both occurring at same time), taken August, 1890.
(8) Loop form of discharge, having a spiral line running its entire length, taken June 10, 1890.
(9) Meandering discharge.
(10) Horizontal discharge, taken June 11, 1890.
(11) Vertical discharge, taken ten minutes later than 10.
(12) Parallel discharge: Two almost parallel lines converging into one main stem, taken April 17, 1891.

It will be noted that in all these photographs the wavy character is maintained, and also that the line grows thicker as the discharge progresses.*

There has been a question raised as to whether (10) really represented a lightning discharge or was merely a defect or scratch upon the surface of the photographic plate. It has been my practice to note in my diary particulars of the storm and a pen-and-ink sketch of the forms of lightning photographed as they appeared to the eye, this being done while the impression was still strongly written upon the mind. The following note appears in reference to (10), and the preconceived sketch, made before the plate was developed, has the same general outline as the photograph:

"June 11, 1890. Most remarkable storm occurred last night. At 10 o'clock took my little kodak and went off into the country. Got some beautiful low horizon effects. At midnight the storm reached us; never saw such marvellous lightning effects; all directions; one incessant blaze of

* We are indebted for the use of a number of these pictures to the journal *Electricity*.

glory; mostly horizontal discharges; saw several streaks turn back on themselves * * * "

The "tree form" (5) will probably explain the production of marks upon the bodies of persons struck by lightning, which have hitherto been supposed to be photographs of actual trees or branches.

Examination of the discharges upon the negatives by means of a strong lens discloses the presence of a transparent line running along its length. Whether this is due to photo-chemical action, or whether the lightning is so divided, I am unable to determine.

When lightning has once opened up a path in space, there usually follows immediately along the same line a series of discharges. If the camera be moved across its path the resulting photograph is liable to show a number of parallel ribbons of lightning, which has given rise to the opinion that it is not an instantaneous flash of light, but a burning streak of flame. No. 6 clearly shows statified lines near its lower extremity, although in this case the camera was rigid at the time of the discharge. I have often noticed the flight of bats during a thunder-storm, and have caught during what was apparently a single discharge of lightning a large number of instantaneous impressions of the wings of the bat in different positions clearly outlined against the sky.

In (11) a number of dark branches diverge from a light main stem. Whether this effect is the result of the reversal of the image upon the plate, or the branches represent yellow bands of light, branching from a white main stem, is an open question.

Franklin Institute.

[*Proceedings of the stated meeting, held Wednesday, December 16, 1891.*]

HALL OF THE FRANKLIN INSTITUTE,
PHILADELPHIA, December 16, 1891.

Mr. JOS. M. WILSON, President, in the chair.

Present, 182 members and sixteen visitors.
Additions to membership since last report, twenty-six.